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March 22, 1928

Engineering News-Record

The Craftsmanship of Guniting

How skill of operators on Cambridge reservoir determined output and quality, told in specific figures

Preliminary Report of Failure of St. Francis Dam

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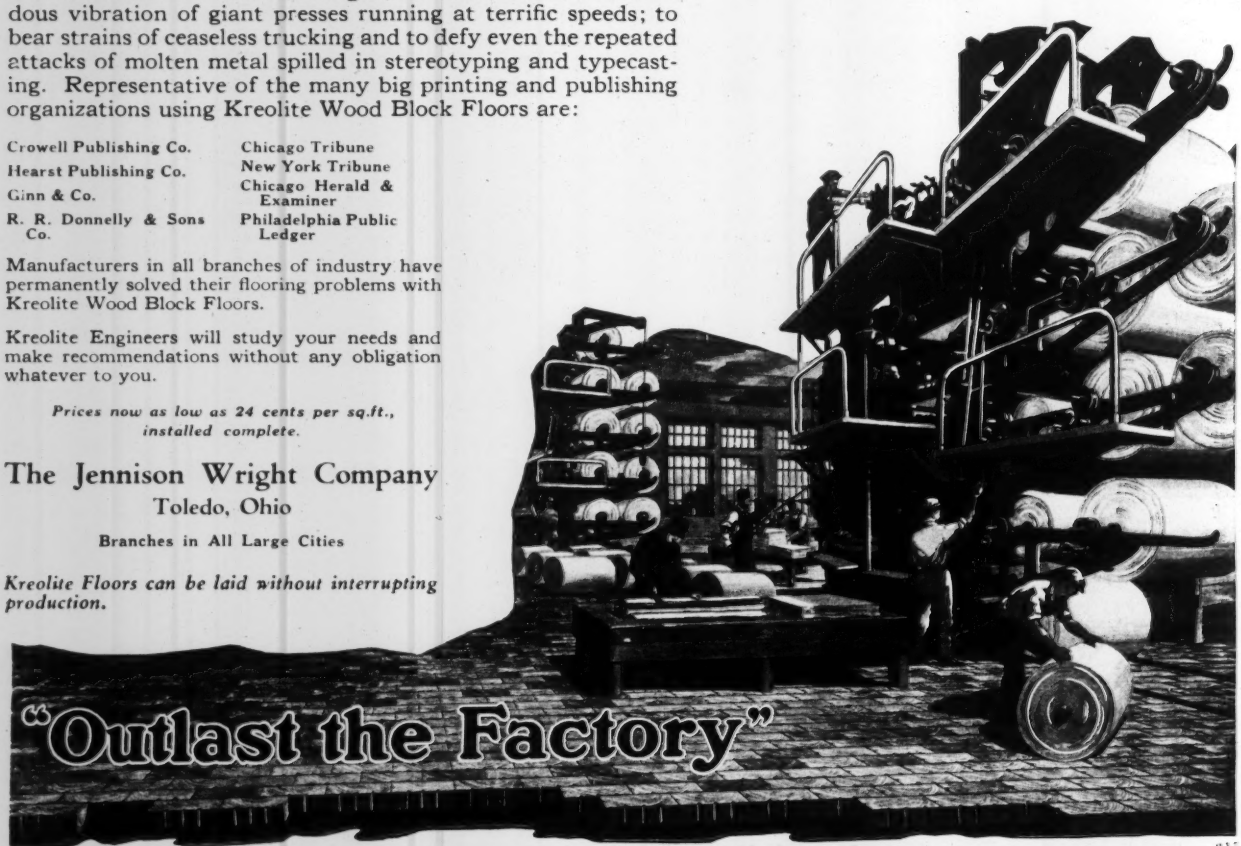

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

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Nature and Man

IN TWO separate blows thousands of miles apart, disaster came down upon many hundreds of peaceable human beings last week. It visited Santos, Brazil, in the shape of a huge landslip. It overwhelmed a quiet valley of southern California through the failure of a massive dam of great height—and here it was not nature, but the errors and limitations of human craft. Both tragedies touch upon fields where man's knowledge is most seriously deficient. Landslips, familiar to all ages and every part of the earth, still remain mysterious and unforetellable; though much is known of earth slopes and their conditions of repose, yet often a stable and quiescent slope has suddenly slipped or crumbled in a great earth avalanche. And similarly, while much is known of foundations for dams and how to build them securely, yet the complex resistances to load, to shear and sliding and to the penetrating action of water often prove to be beyond our grasp. But human knowledge is ever advancing, in these fields as in others. Out of the two disasters better knowledge must come.

Craftsmanship in Guniting

GUNITING as a test of craftsmanship is stressed in the description in this issue of the work of lining the Cambridge reservoir. The article makes it clear that, if gunite is to be a sound adhesive covering and if guniting is to be fast and economical, experienced and skilled gunmen and nozzlemen, trained in teamwork, are essential. This is an important truth for contractors to get in mind. The lining work at Cambridge required only rather ordinary craftsmanship. Skill in guniting extends much farther, to the ability to build to true plane or curved surfaces, to precise thickness and to true lines and sharp arrises. These are no small attainments of precision and skill, as any one may see who is familiar with the process of blowing sand and cement and water at gunshot speed through a nozzle and making the flying missiles keep their place. These extra precise operations obviously call for the craftsman specialist. The more ordinary applications of gunite, as in the case of the Cambridge reservoir, are and must be handled by the workman whom the contractor can command with reasonable certainty and who perhaps must be trained to the task. It is in these circumstances that the article in this issue is helpful, first because, as already said, it stresses the fact that good guniting is not haphazard, and again because it gives suggestion and data which can be put to practical use in the field.

Half Retrieved

LAST Saturday the salvage forces raised the submarine "S-4," sunk off Provincetown last December. Three months to a day the ill-fated vessel lay on the bottom The Navy is entitled to commendation for its persistence and energy in the raising. Winter weather and storms and a hundred-foot depth of water were not allowed to discourage the toilers. The lost ship and the lost men had to be brought home; and now they have been brought home. But the men are dead. It is no more comfortable today than it was three months ago to think that they were doomed at the moment when the ship took its fatal plunge, that they had to die because of the absence of means of rescue. The sinking of the "S-4" is only half retrieved by the salvage. There remains the grave duty of investigating all matters of safety to life on submarines, to the end that their crews in future may have the fullest protection that modern engineering skill can give.

Accidental Drowning

NOT all high death rates from accidents are due to automobiles. Occasionally one gets a certain amount of consolation out of comparative statistics such as those recently issued by the Wisconsin state engineer's office, which indicate that the deaths by drowning increased from 184 in 1923 to 216 in 1927, whereas railroad fatalities dropped from 125 to 101 and street cars reduced their toll from 30 to 18. The automobile in the meantime doubled its death record—252 to 505. Thus drowning is second to the automobile as a growing danger. To assist in reducing the high drowning loss the state Board of Health has issued a bulletin giving rules for resuscitation, which are sent each year to municipal and other officials to assist in the general education of the tourist and outdoor interests. One may properly expect such efforts in a state in which supervision over sanitation facilities is so close that it can report the number of rural wells, private water supplies and private sewage units (11,000) and where it is known that 10 per cent of the farm houses in the more developed counties are equipped with plumbing. There are 300 tourist camps, and 75 camps are provided specially for boys and girls. Under these circumstances it is quite in order to provide supervision over available "swimming holes" and to endeavor to make swimming less hazardous. Perhaps it is not an engineer's job, but the safety measures that he provides in building swimming pools may well be appraised for adaptation at the natural pools.

Taxation Without Representation

PERNICIOUS interference in local affairs is none too strong a characterization of the Indiana scheme of state control of municipal budgets outlined on p. 276 of our issue of Feb. 16. Under the statute in question the tax rate and budget of any local taxing district in the state may be thrown into the control of the state Board of Accounts, provided ten taxpayers petition the board for a hearing. After the hearing, the state board establishes the tax rate and modifies the budget accordingly. Given a state board of one political complexion and a

local governing board of another, all that is needed to rob the latter of financial control is a petition signed by ten taxpayers of the opposition party and the state board can take charge of the tax rate and budget. Regardless of partisan politics, which are about as bad as possible in the Hoosier state, the statute is pernicious and unjust. Indiana must have either a queer Constitution or queer courts if such a thing is legally possible. It is a back-handed way of attempting to legalize taxation without representation—long ago proved to be intolerable in this country.

Self-Government Denied

NOTWITHSTANDING a large popular majority vote for a council-manager charter at Newport, R.I., in November, 1926, the state Legislature of 1927 failed to pass the necessary act to put the will of the people into effect. The Legislature of 1928 seems averse to favorable action, but has gone farther than the 1927 Legislature by granting more than a perfunctory hearing to the friends of the council-manager charter. In many other states of the Union a three to one vote in favor of a new charter would settle the matter, because of statutory home rule powers in charter framing. In California, where legislative ratification of a locally drawn and adopted charter is necessary to make it effective, the Legislature has never refused approval in many years. Much of the opposition to the Newport charter appears to be based on fear that it will result in non-partisan government, or at least make the road of the state politicians a less easy one to travel. This was made evident at the recent legislative hearing, where the most frankly expressed objection to the proposed new charter was that under it "practical methods are discarded for pure theory and experiment," all "in a wild attempt to discard politics and substitute in its place a glorified non-partisan" plan of conducting public affairs. A stronger argument for the council-manager plan could not be advanced. The right of Newport, or any other city, to give the council-manager plan a trial cannot long be denied by those who place political party above the right of self-government.

A Questionable Compromise

WHETHER to congratulate or commiserate the New England Water Works Association and its committee on cross-connections for the report by the latter, abstracted at some length elsewhere in this issue, depends altogether upon the point of view of anyone who attempts to decide between the two alternatives. The report is an undoubted compromise between those whose primary concerns are on the one hand the public health and on the other the prevention of fire losses. The conclusions of the report and the resolutions presented for adoption by the association show concessions on both sides. These may perhaps be greatest on the side of those whose chief concern is fire protection to factories and mills, but through the use of qualifying language the resolutions can be readily used on occasion as arguments for permitting the extensive use of cross-connections any of which might be a constant menace to health, while some might cause serious epidemics.

Before going further into the subject, it should be noted that for years past there have been arguments before the American and New England Water Works associations on this matter of cross-connections and that most of the time and energy expended in their defence has proceeded from a very few fire protection engineers, constituting only a small percentage of the membership of the associations. These engineers have been representatives of some of the Factory Mutual Fire Insurance Companies. Engineers representing the commercial fire insurance companies of the country have expressed themselves strongly of late as in favor of the abolition of cross-connections.

The most essential parts of resolutions already adopted by the State Sanitary Engineers and the American Water Works Association are identical. They unequivocally urge the prohibition of any physical connection between a potable public water supply and any other supply, except where the other supply is either also a "potable public supply" or else a "potable supply [other than public] which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made."

In contrast to this flat-footed prohibition of connections between potable public supplies and any non-potable supplies, the New England resolutions open up by urging, in effect, the development of public water supplies to such an extent that no cross-connections would be necessary, even advocating provision of "a secondary potable supply if necessary." The second resolution recommends abolition of all cross-connections, but qualifies it by adding "without undue fire hazard to life and property." Then after providing that until all cross-connections are eliminated double check valves of an approved type should be used, the fourth resolution seems, on first reading, to take the same stand as the resolutions of the State Sanitary Engineers and the American Water Works Association in urging the prohibition of cross-connections between polluted supplies, but careful reading of the New England resolution indicates that it means only that cross-connections should not be permitted with raw water so bacterially unsafe that it could not be rendered safe by purification.

Taken in conjunction with other portions of the report and particularly with the first paragraph of the "Conclusions of the Report," the resolutions leave wide open a chance for a battle royal when up before a state board of health for guidance in working up rules and regulations, and particularly when a campaign is being waged in a given community for the abolition of cross-connections.

It is unfortunate that the New England Water Works Association committee could not take substantially, if not actually, the same stand as did the American Water Works Association and the State Sanitary Engineers instead of submitting resolutions looking both ways. The function of such an association in adopting resolutions would seem to be to provide something reasonably approaching the ideal, leaving to a state regulatory body the framing of rules and regulations that would meet the peculiar needs of its own state, with expectation also that the state regulations would leave a certain amount of discretion to local governing bodies, and with the certainty that the courts always stand ready to put aside unreasonable and unduly burdensome regulations.

In matters of public health the benefit of any doubt should be in its favor. In this report the spirit and method of compromise seem to have gone too far the other way. Fortunately the resolutions are still open to amendment.

The St. Francis Dam Disaster

A GREAT dam has gone out. For the first time in history a high dam of massive masonry has failed, and every fear of the destruction pent up in such works is realized. In human respects the memorable Johnstown catastrophe of 39 years ago was greater. But the washing out of an old neglected earth dam was not an engineering tragedy, as was the destruction of the St. Francis dam. Here the highest embodiment of modern dam-building science crumbled into ruin, taking a toll of hundreds of lives as the price of mistaken confidence in its strength. Only a day before did the engineers who built it examine the great structure and pronounce it safe; yet it failed.

Men have always been in awe of these vast forces, and often has bitter protest been made against the erection of a dam above populous communities. In every instance engineering science answered the protest and gave assurance that the waters would be safely controlled. The destruction of the St. Francis dam challenges that assurance.

No final statement of why the dam failed can be made until the official inquiries already begun are concluded. But Mr. Bowers' examination of the site as reported in the following pages points unmistakably to fatal weakness in the foundation. The towering structure was built on rock so unresistant that the few hours of flood outrush eroded and tore it away to a depth of many feet. It had been built without grouting the foundation, and apparently without adequate anchorage of the structure by deep notching of the rock base. These conditions, in conjunction with the facts that may be read from the wreckage itself, tell a clear story.

Extraordinary circumstances appear in the wreckage. The central section of the dam still stands erect, by all present evidence in undisturbed position. But to either side is a great breach; both wings of the dam are gone. That the violent wrenching and shock of this breaching, superadded to the full pressure of the impounded water, did not displace the high middle section is a remarkable demonstration of stability; it inspires thorough confidence in the principles of gravity dam construction.

Yet the wings, though equally strong as the center, were broken to fragments. Earthquake shocks and the violence of explosives are scouted as possibilities. Foundation failure alone can account for their destruction. But of what nature was this failure?

There is a striking difference between the two breaches. The gap on the right bank is bare of concrete. It was swept clean by a torrential rush that carried enormous masses of concrete half a mile down the valley. The left gap was not thus cleared, but remains choked with fallen fragments. No powerful rush of water swept through this gap; no great flow can have passed out here until the reservoir level had fallen greatly—fallen, evidently, as a result of the tremendous outpouring at the right end. The right section, it appears, was the first to go out.

The original foundation surface of the right section cannot be examined. It is gone, eroded by the flood. Even the harder rock in the valley bottom was deeply cut, while above, in the upper half of the west shoulder, the rock was of such nature that it softened in water. Through the rock, or between rock and base of dam, there came seepage water. The wing which abutted here has disappeared, together with the hillside.

No information is at hand as to how deeply the dam was seated in the rock, but the section reproduced by Mr. Bowers does not show a foundation trench or offsets. In its highest part each lineal foot of the dam was subjected to a downstream push of a million and a quarter pounds tending to shove it from its place. Lacking any notching, this push had to be resisted by friction under the vertical load of two and a half million pounds and the interlocking of concrete with the rough rock surface, or else by the shearing strength of the rock itself.

But the conditions in the left section also call for notice. Here sliding due to the push of the impounded waters cannot be in question, for the evidence of the wreckage shows that failure occurred after the water was drawn down. The hillside here is covered by a great slide, and some of the huge fragments of the dam have been hurled out of place toward the thread of the stream, mute evidences of a gigantic force acting outward from the bank.

The destructive force here was plainly not water pressure, but hillside thrust. The slope which has come down burst away from its supporting layers with a violence so great and with such deeply extending effect that it uprooted the very foundation strata of the dam and broke the superstructure into random blocks. This action, occurring after the sudden draw-down, was the evident result of the outward pressure of the water in this saturated slope. That such action could take place indicates an alarmingly high absorptive power of the rock in the hillside and equally alarming weakness of the rock both here and at the valley bottom. Such rock was little adapted to offer great resistance to shear at the foot of the west slope; and with still weaker rock overlying at the west end it had to do double duty. The scarred and broken-out westerly hillside is the result.

Seventeen years ago a dam at Austin, Pa., only one-third as high as the St. Francis dam, broke by sliding out, due to the shearing of the rock strata into which it was notched a very few feet. The critical danger of sliding was plainly manifested in that failure. With far greater height and with the sliding danger multiplied in much greater ratio, the St. Francis dam depended on the strength of rock strata apparently no better than those at Austin.

When the findings of the local inquiries become available it is possible that this roughly sketched explanation may be modified. But we believe that its essentials are likely to be sustained. If so, it will furnish no reason for fears about the strength of existing dams. On the contrary, it will confirm rather than question the knowledge by which they are built. It will indict only those errors of misjudgment or neglect that can upset all theory.

High dams can be built safely, and dams now standing are safe. Engineers universally recognize the great truth that care in building the foundations is the weightiest matter in dam construction. Nor does the St. Francis failure furnish a valid argument against building on rock of less than the hardest kind. Many important dams resting on poor rock have stood long and safely, because the quality of the material was rightly appraised and the construction planned with full consideration therefor. The present disaster, then, contains no fact or happening that would justify restriction of dam construction. It points the need, however, for an effective check on individual judgment concerning foundations where many lives are at stake.

St. Francis Dam Catastrophe

—A Great Foundation Failure

Wings of 205-Ft. Concrete Dam Washed Out, but Central Section Remains—Reservoir Pours 38,000 Acre-Feet of Water Down the Valley in a Torrent a Hundred Feet Deep, Bringing Death to Hundreds—Power House Swept Away—Flood-Water Head Bursts Aqueduct Below

By Nathan A. Bowers
Pacific Coast Editor of Engineering News-Record, San Francisco

At the First News of the catastrophe Mr. Bowers left San Francisco for the scene of the break. His observations, photographs and sketches were made within 36 hours of the failure and thus present the original conditions. Besides studying the wreckage, he interviewed the engineers who built the structure and also checked his observations against those of the leading Los Angeles engineers skilled in dam construction and familiar with local conditions. His telegraphed report, which follows, sets forth clearly the unprecedented character of the failure in the crumbling of both wings, the tremendous power of the flood's sweep through the west breach, the less tumultuous destruction of the section in the east breach and the erosion and tearing out of the soft rock strata on which the dam had been built.—Editor.

THE St. Francis dam of the Los Angeles Aqueduct, the collapse of which in the night of March 12 was announced in last week's issue, adds to the list of foundation failures the most terribly tragic instance of modern times. Without the slightest warning the great structure suddenly broke up; a single piece remained standing, while the rest slumped to the valley floor or was swept out. Great blocks of the concrete mass, weighing many thousands of tons, were carried half a mile or more down the canyon. The collapse occurred just at midnight, a time when the people living in the valley below were asleep. They were caught without opportunity for escape. When this was written (March 16) the toll in life and property had not yet been fully reckoned, but a total of 205 bodies had been recovered, while 200 persons were still reported missing.

The dam was a concrete structure of the gravity type, though arched in plan. It was located in San Francisquito Canyon, about 1½ miles above Power House 2 of the Los Angeles Power Bureau, roughly 45 miles north of Los Angeles. The reservoir which it formed had a capacity of 38,000 acre-ft. and was practically full at the time of the break. Ten or eleven miles below the dam San Francisquito Canyon empties into the Santa Clara

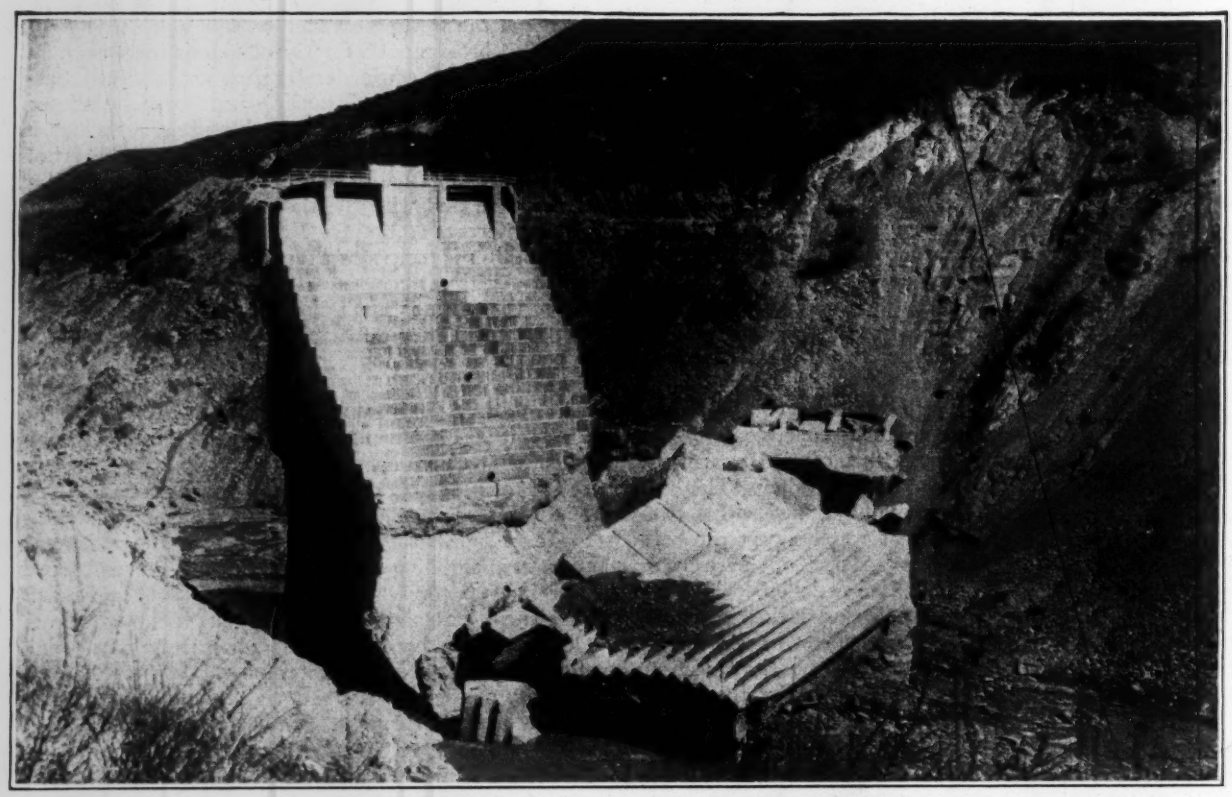


FIG. 1—EAST ABUTMENT LOOKING UPSTREAM

Rock face against which dam abutted completely gone or covered by landslides. Fragment of this (east) end of dam fell close to original position, while fragments of entire west end were swept downstream, indicating that the west end failed first. Position of fragments of east end indicates that failure was caused by sliding out rather than overturning.

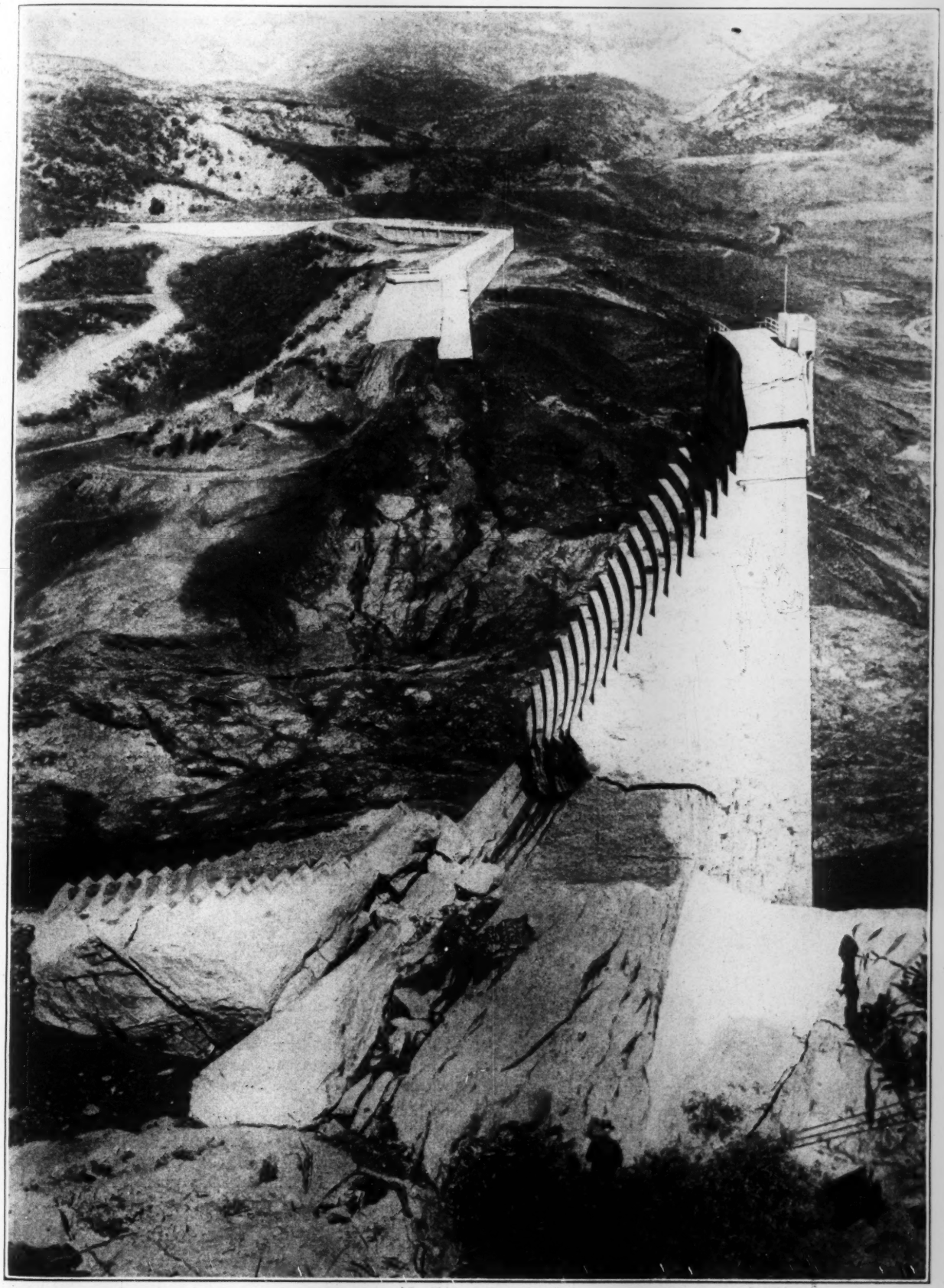


FIG. 2—ST. FRANCIS DAM SITE LOOKING WEST FROM THE EAST ABUTMENT
Portion of dam remaining upright believed not to have moved. Stepped portion in lower left center came from near east abutment.

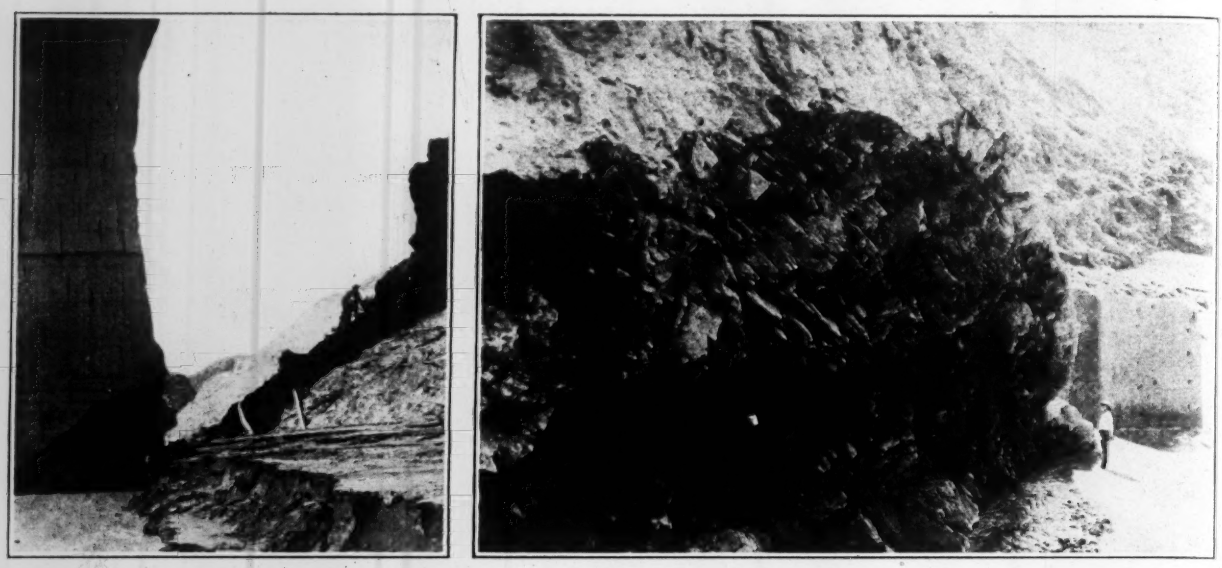


FIG. 3—DETAIL OF THE STANDING PORTION

Left: Looking downstream, showing undercutting. Right: A close-up of the undermined west side showing extent to which this portion was undercut. The bottom of the concrete can be clearly seen near the upper portion of the picture.

River, which flows thence westerly about 50 miles to the ocean, passing through Piru, Santa Paula, Saticoy and other small cities. The flood wave resulting from the abrupt discharge of the reservoir washed away the concrete power house, buried great stretches of valley under silt, and extensively damaged bridges, highways and the Southern Pacific Railroad branch line that follows the Santa Clara River. It reached Santa Paula, 46 miles below the dam, three hours after the break, thus averaging about 15 miles per hour, or *22 ft. per second*, in its advance. Rough estimates based on channel section and assumed velocity indicate that the peak flow exceeded 400,000 or 500,000 sec.-ft. By 6 a.m. the flow had subsided to bank storage and return waters.

FIG. 4—WEST ABUTMENT FOUNDATION

Material above contact plane is agglomerate and conglomerate. Below it is various grades of shale. Note undermining of portion of dam still in place at upper center.

In the tortuous San Francisquito Canyon the flood crest washed high up the steep slopes wherever its path was diverted; in the tangents it ranged at lesser heights, 75 to 100 ft. The rushing waters swept the canyon sides clean for miles.

On the one section of the dam that remains erect, the central section, there was installed a recording gage with clockwork attachment, functioning at the time of the break. The gage has not yet been reached to see whether it will show the rate at which the reservoir level lowered, but if its operation was not interrupted—and the housing seemed to be intact—its record will be of great hydraulic value. Other information on the rate of advance of the flood crest down the canyon is expected when the exact times of "bumps" on various power lines affected can be checked and compared.

The Dam and Its Foundations

The dam was designed as a gravity section, and though it was curved in plan, no arch action was counted on. The foundation pressure at the toe was limited to 10 tons and at the heel to 12 tons per sq.ft. Concrete was taken to weigh 140 lb. per cu.ft. (a sample was found to weigh 135 lb.), and allowance was made for hydrostatic uplift. The maximum section was 205 ft. high and had a base width of 176 ft.; the curve of the dam in plan had a radius of 500 ft.

Excavation for the foundation extended 30 ft. below stream bed at mid-channel and to lesser depths at higher elevations. Two kinds of rock occur in the foundation, meeting on a well-defined plane visible on the clean-swept side of the canyon. Under the stream bed and on the left bank there is found a rock rated geologically as a schist, but known locally as graywacke shale. The right bank above the contact plane is usually referred to as a red conglomerate. While some of this rock was not of the best quality, it was nevertheless accepted as a suitable

foundation, and excavations in the rock of base and abutments were made deep enough to provide what was considered safe anchorage.

Drains and Seepage—No grouting of foundations was done, but it is stated that in the stream bottom holes were sunk 20 to 30 ft. deep 10 or 12 ft. on centers in the foundation trench about 15 ft. back from the upstream face. Four-inch pipes were brought out of these holes and led through a common drain outlet on the downstream face at stream-bed level.

There was no inspection tunnel, no concrete cutoff wall, and no reinforcement in the dam.

The dam had impounded water last year, but on present information the reservoir had not been full until

FIG. 6—GAP AT EAST SIDE OF DAM
Landslides have covered much of the rock surface exposed by the washout.

shortly before the break. Valley residents had been apprehensive about the dam and there was local talk about dangerous seepage. These rumors have not been substantiated. William Mulholland, chief engineer, and his principal assistant, H. A. Van Norman, were at the dam the day before the break, presumably to investigate the reported seepage. Mr. Van Norman stated to the writer that he personally observed the seepage beneath and around the dam at that time and found only a reasonable quantity, which was clear as usual. There were no signs of any sort that would indicate danger to the structure, he stated.

This dam contained no vertical joints, as it is not the policy of the Los Angeles water bureau to make provision in design for contraction joints, but rather to allow con-

FIG. 5—LOOKING WESTWARD TOWARD WEST ABUTMENT
Standing section in foreground. All portions of west end of dam were swept downstream, indicating that most of the water went out at that side.

traction cracks to occur where they will and later close them as may be necessary. Contraction cracks occurred in the St. Francis dam in approximately radial planes, but these were not of such nature as to effect the stability of the structure.

No earthquakes were noticed at observatories in southern California at the time of the break. The possibility that the failure might have resulted from the work of dynamiters is considered wholly out of question.

Condition of the Wreckage

After the crumbling of the dam, only a 100-ft. length near the center of the original 650-ft. length remained standing erect. This erect section, that withstood the shock and vibration of having both ends wrenched away, is still in its original position, in so far as this can be judged without a survey. This appearance is borne out by the fact that at the base of its right (west) side, where the stream is now flowing, there is no sign of crushing such as would be almost certain to appear if so great a weight had moved on rock of this character.

On both sides of this erect section are great gaps, each about 300 ft. wide, in which nothing remains as it was before the break. But there is a remarkable difference between the two gaps. That on the right or west bank contains not a vestige of concrete, all fragments from this portion of the dam having been swept far downstream. Pieces up to 30x50 ft. in size, projecting as much as 40 ft. above the débris, are strewn down the

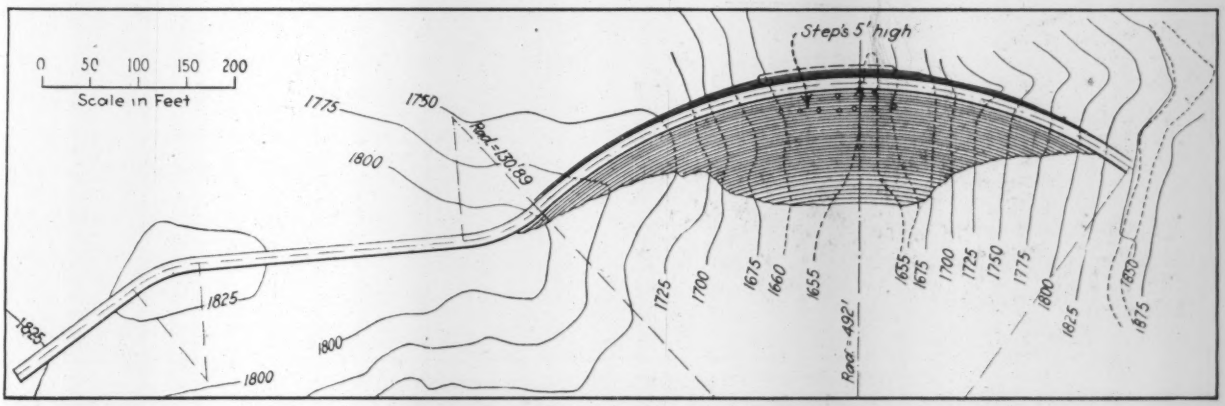


FIG. 7—PLAN OF THE ST. FRANCIS DAM, ALIGNMENT ABOUT HW-SE

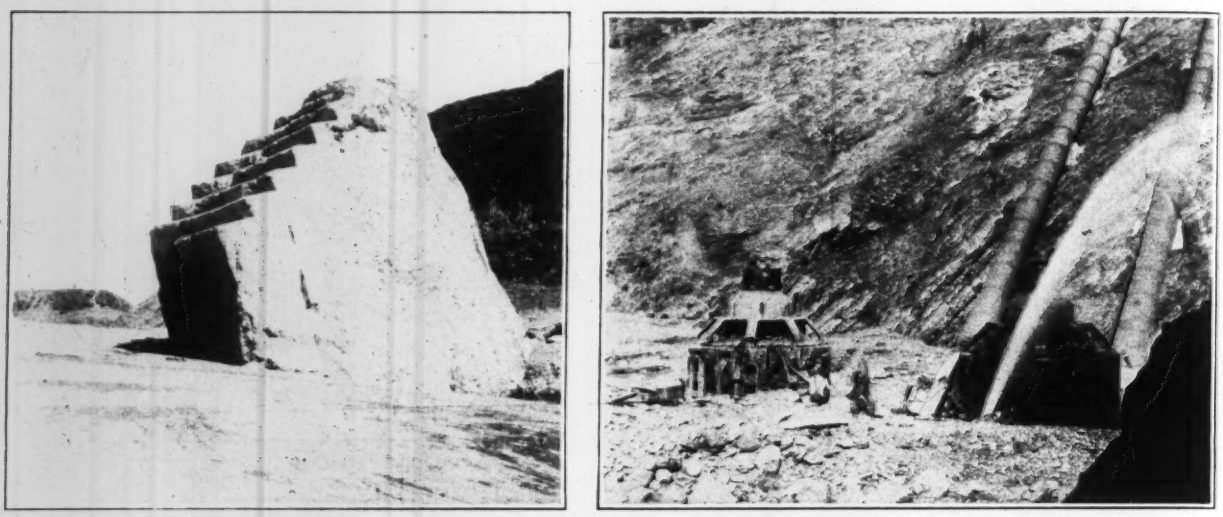


FIG. 8—LEFT—FRAGMENT NEARLY ONE-HALF MILE BELOW DAM. RIGHT—ALL THAT REMAINS OF POWER HOUSE NO. 2

Fragment at left believed to have come from west end of dam. This piece was carried around two bends in the stream. Reinforced-concrete structure which housed the generators at the right was completely swept away. This point about one-half mile below dam.

channel below the dam. Not one of these fragments came to rest in the first thousand feet, and some large ones are more than half a mile from the dam. The gap on the left or east bank, on the other hand, is choked with large fragments from that part of the dam, all but one of which are piled up actually within the gap, the single exception being a large piece resting against the downstream face of the erect central section. So far as can be judged, the entire dam section is represented by these fragments.

Some fragments of the dam have rock still adhering to their base.

The concrete of the structure was strong and sound enough to shear through the aggregate.

The fact that all the fragments from the right gap were carried far while those from the left gap were moved but little indicates that the initial failure occurred on the right side of the stream. Possibly the vibration and shock attending the breaking off of the great pieces on the right end of the dam reacted disastrously on that portion near the left bank. Whatever the initial cause, since both ends carried away while flanked on the one hand by a stable dam section and on the other by their hillside abutments, it seems obvious that they had poorer foundation than the central section, which after all the disturbance remains erect without support.

Foundation Rock Deeply Eroded—On the right bank the rock is now bare from stream bed to crest level. This

FIG. 9—CONCRETE FRAGMENTS SWEPT DOWN THE RIVER

Fragment of dam at left nearly 2,000 ft. below dam, one at right center about 1,000 ft. Men standing at right side of latter block give a measure of its size.

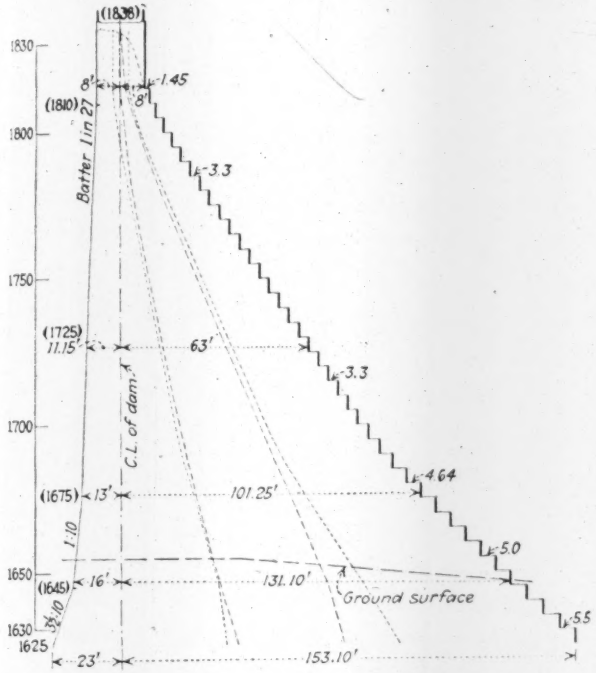


FIG. 10—MAXIMUM SECTION OF ST. FRANCIS DAM

portion of the canyon cross-section, now exposed, has been eroded considerably below the surface on which concrete was poured. Just how much erosion occurred cannot be said until there has been a survey, but it amounted to at least 15 ft. in some places. This bank now slopes downstream as well as toward the valley.

Two distinct formations meet in a contact plane on this bank, about 50 ft. above stream bed (see sketch, Fig. 11). Along the contact is a band of serpentine of seamy formation so softened by water that here and there veins can be picked out with the fingers. Above the contact plane the formation has the appearance of red conglomerate, but *typical samples submerged in water were found to soften in a short time.* Evidently the foundation is not now as firm as it was before saturation, when the concrete was poured.

On the left bank the abutment against which concrete was poured also appeared to have been cut away by the flood, but earth slides have covered the face of the slope so that the rock itself cannot be examined. Raymond A. Hill suggests, in explanation of the breakup on the left bank, that after the right end had gone out the undercutting action of an eddy below the dam due to the flood through the break plus the impact of a slide induced by the action of the sudden draw-down on the saturated banks may have produced the condition obtaining in this portion of the wrecked structure.

There is a striking illustration of the foundation conditions in a view of the base of the right (west) face of the erect central section (Fig. 3). Here rock is seen adhering to and hanging from the under side of the concrete dam body, which still remains in original position. In other words, the foundation on which concrete was poured has been here undermined for a depth of 15 ft. or more below the bottom on the excavation, and rock is shown adhering to the undermined concrete on the under side of the dam.

Just where the failure began and what was the sequence of the breakup will probably never be known positively. The several investigations now under way may bring to light further data that will alter the aspect of the situation, but the consensus of opinion (March 16) among engineers who had examined the break was that foundation conditions were at least an important factor, if not the sole cause of the break. The question of how far grouting would have prevented water from getting into the foundations and how much of a factor this would have been in preventing the break is also being discussed.

St. Francis dam was built for storing aqueduct water that already had passed through Power House 1, but which it was not desired to pass through Power House 2. When the aqueduct was first put into operation, water was allowed to flow down the natural channel from Power House 1 to be picked up again at an intake below. When Power House 2 was added, with its tunnel leading from just below Power House 1 to a forebay above Power House 2, there was thus provided a second route by which water could travel between the two plants to the same tunnel intake, which was then incorporated in Power House 2. The dam was built purely to regulate and conserve aqueduct flow. The 36 square miles of area tributary to St. Francis reservoir was not used as a catchment basin except for flood waters; in fact, by agreement with water users below, the flow released from the dam into the channel and not again taken into the aqueduct was kept equal to the runoff from the drainage area into the reservoir.

Flood Head Bursts Aqueduct

The aqueduct tunnel immediately below Power House 2 is 3 miles long and empties into Dry Canyon reservoir. At the time of the flood the intake at Power House 2 was open, and the full head of the flood level, about 100 ft. above the intake level, was thus effective on this tunnel. Three breaks totaling 412 ft. in length resulted from this abnormal pressure at points where the conduit changes for short distances from tunnel to aqueduct section. Because of the destruction of roads in the canyon and the consequent inaccessibility of the breaks, Dry Canyon reservoir was drawn down below the outlet level and materials and crews for repairing the breaks were sent in through the tunnel. The tunnel section is such as to provide for a 1,000-sec.-ft. flow on a grade of $1\frac{1}{2}$ in 1,000. The uppermost break was $2\frac{1}{2}$ miles above the

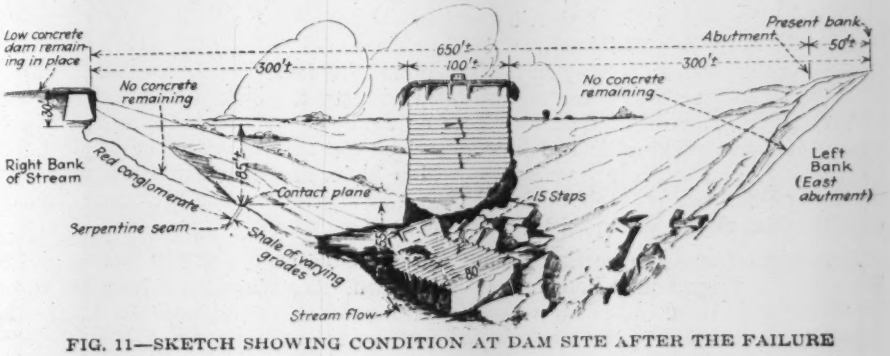


FIG. 11—SKETCH SHOWING CONDITION AT DAM SITE AFTER THE FAILURE

outlet. Repair of these breaks, which was estimated to take less than a week, will enable the aqueduct to function in its entirety again. Meantime the city draws upon the large storage reservoirs at the lower end of the aqueduct.

Various municipal, county and state organizations and departments have begun moves toward investigation of the cause of failure. The Los Angeles City Council has asked Elwood Mead, U. S. Commissioner of Reclamation, to act as chairman of an investigating board to be composed of engineers nominated by the American Society of Civil Engineers. The Board of Supervisors of Ventura County, which was traversed by the flood, appointed an investigating committee. The attorney for that county has suggested the organization of a board of claims to see that full reparation for damages is made. He is quoted as stating that Ventura County will spare no effort to fix the legal responsibility on Los Angeles on the ground of negligence in the manner in which the dam was constructed. The Governor of California has appointed F. H. Fowler and F. E. Bonner as an investigating board.

R. F. Goudey, district engineer of the State Board of Health, is in charge of sanitation measures in the flood-stricken area, particularly the temporary treatment of sewage where sewage-disposal systems are out of commission. Effective work was done in the flood-stricken area by the Red Cross. Aid from all sides, favored by good weather and uninterrupted communications, greatly expedited rescue and repair work.

St. Francis dam was designed by the Los Angeles Bureau of Water Works and Supply, William Mulholland, chief engineer, and built by the same bureau by day labor.

It was planned and built without check or supervision by the state. The California law (of 1917), which requires plans for all dams to be approved by the state engineer, exempts those built by the California Debris Commission, municipal corporations which have a department of engineering, and water systems under the jurisdiction of the state railroad commission.

FIG. 12—ST. FRANCIS DAM SHORTLY AFTER IT WAS COMPLETED

Notable Dam Failures of the Past

English Dam—A rock-filled crib structure in Sierra County, California, failed in June, 1883. It was 331 ft. long on the crest, 50 ft. long on the bottom and 100 ft. high. Originally a wood-crib structure filled with stone, a heavy stone facing had later been placed on the downstream face and flashboards had been placed on top of the dam. At time of failure water was within 2½ in. of the top of the timber flashboards. When these gave way, the dam rapidly crumpled to its foundations.

Johnstown Dam—An earth structure on the South Fork of the Conemaugh River above Johnstown, Pa., failed May 31, 1889. The dam was 930 ft. long, 75 ft. high, with a 10- to 12-ft. crest width. The cross-section of the dam was made up of a paved impervious soil in the upstream half, and a rock, gravel and sand fill on the lower half. There was no core wall or puddle of any kind. The dam had been built 50 years earlier to serve as a reservoir for the Pennsylvania state canal system, abandoned in 1857 and patched in 1879 to provide a lake for a hunting and fishing club. The cause of the failure was overtopping, contributed to by a lowering and a dishing of the crest, the closing of a pipe tunnel outlet and the obstruction of the spillway. With more than 2,000 lives lost, this disaster has been characterized as the worst in history resulting from failure of man-made structures.

Walnut Grove Dam—A rock-fill structure at Prescott, Ariz., failed Feb. 22, 1890. The structure was 110 ft. high, 140 ft. wide at the base and 10 ft. wide at the top. It was 400 ft. long on the top and 100 ft. long on the bottom. Both faces were paved with large granite blocks. The upstream face was covered with heavy lumber for watertightness. The failure, which was complete, was attributed to a too small waste weir, causing backing up of water and overtopping. There were 150 lives lost.

Austin, Tex—A masonry overfall dam paved with granite on the upstream and downstream faces failed April 7, 1900. The dam was 60 ft. high above stream bed by 1,091 ft. long. A preliminary failure had occurred before, when a layer of loose material in the rock below the foundation of the headgate masonry washed out. This had been repaired, but there still was leakage in 1900. On April 7 the flood swept out a portion of the dam 500 ft. long, virtually lifting it up and shoving it downstream about 50 ft. The failure was described as "sliding out bodily on its base of that portion which failed." It was also said that this sliding resulted from faults in the limestone bottom which permitted the dam to settle, breaking it loose and permitting it to be pushed downstream. Eight persons were drowned in the power house.

Anderson, N. C.—Masonry dam, gravity section 44 ft. high and something over 25 ft. wide on the bottom. Twenty feet of the height and 10 ft. of the width had been added to the original structure by anchor bolting. The dam was overtopped with 7½ ft. of water and the upper section overturned Dec. 28, 1902.

Columbus, Ga.—Masonry dam, failed Dec. 28, 1902. It was 550 ft. long and 39 ft. high, including 3-ft. flashboards. About 350 ft. of the dam went out when it was overtopped by 10 ft. of water. Failure occurred from 5 to 20 ft. below the crest of the masonry.

Lower Tallassee Dam—A masonry structure at Tallassee, Ala., failed Dec. 28, 1902. It was 1,300 ft. long, 30 ft. high, 6 ft. wide on the crest and 23 ft. wide on the bottom. For about 700 ft. of its length it was curved upstream. Most of the tangent lengths went out when the dam was overtopped by 7 ft. of water.

Hauser Lake—An unusual dam structure across the Missouri River near Helena, Mont., consisting of steel bents supporting curve plates for the water surface, failed on April 14, 1908. It was 630 ft. long and 70 ft. high. The end bents were located on rock, but about 400 ft. of the dam in the center of the stream was founded on a water-bearing gravel of unknown depth. The steel plates were sloped 1½:1, utilizing the weight of the water against sliding, and were also anchored by steel sheetpiling. A rubble masonry fill under the plates downstream from the piling was placed to prevent seepage. However, enough water seeped under the dam to cause one steel bent anchorage to give way. Water passing through this opening washed out the masonry fill and rapidly cut away the gravel foundation until about 300 ft. of the steel bents progressively failed.

Austin, Pa.—Gravity concrete structure failed Sept. 30, 1911. This complete failure followed a preliminary one some years before which had never been completely repaired. The dam was 30 feet wide at the base, 2½ ft. wide at the top, 544 ft. long and 50 ft. high, with a 4x4-ft. cutoff wall in rock. The structure was of cyclopean concrete. On the first failure, which was thought to have been caused by pressure on the dam before the concrete had completely set, small cracks appeared and water got under the dam, causing it to drop down about 6 in. at the toe and slide out about 18 in. at the spillway. The foundation material consisted of alternate layers of sandstone and shale, and it is believed the water seeped through the shale stratum. The dam was left in this condition with water seeping under the foundation until it went out by sliding on the date noted.

United States Dam—Ohio River Dam 26, near Gallipolis, Ohio, failed Aug. 8, 1912. It was a movable dam of the Chanoine wicket type and in addition included a weir and a masonry lock. Six hundred feet of the wicket section moved downstream. The dam was founded on a concrete slab resting on shale. Failure resulted from horizontal shear of the shale.

Port Angeles, Wash.—High concrete gravity structure on the Elwha River failed Oct. 30, 1912. The dam spanned a gorge about 35 ft. wide and was 110 ft. high. It was straight in plan, but of peculiar design. Trouble was experienced in getting a cutoff wall to rock, both a cofferdam and a sheet-piling method being attempted. Finally the bottom concrete was laid under water. Failure occurred by the washing out of gravel and sand underneath, the dam being left spanning the steep sides of the narrow gorge. It was not damaged except in the foundation.

Stony River—Hollow reinforced-concrete dam with a sloping deck near Dobbin, W. Va., failed Jan. 15, 1914. It had been completed about six months and was 50 ft. high. The cutoff wall did not go to rock at the point where the five bays went out. Leakage had showed at least a day before the break. The floor of the dam had been founded on clay or hardpan and the cutoff wall at the heel of the floor was generally 5 ft. deep below the floor, and in some places went to rock. The failure occurred first in the floor by flexure, which let the deck and buttresses fall. The dam was in a remote location, and little damage was done.

Plattsburg, N. Y.—Hollow concrete dam of the sloping deck type failed May 15, 1916. It was completed in 1915 and included 22 bays; it was 330 ft. long, 42 ft. wide at the base and 35 ft. high. No one had assumed responsibility for the structure; there was no city engineer when it was built. The dam was built on glacial drift and seepage was noted under the toe, but was neglected. In fact, the lower weep holes had been plugged by some city official. Six bays of the dam washed out at one end when the foundation failed.

Lower Otay Dam—Rock-fill structure of San Diego water supply failed Jan. 27, 1916. The dam was 130 ft. high and depended for watertightness on a riveted steel-plate diaphragm. The masonry foundation was carried 31 ft. below stream bed with a maximum thickness of 65 ft. The dam had leaked for a long time, and when a heavy rainfall overtopped it the dam washed away in about fifteen minutes. Thirty lives were lost.

Lake Gleno—A combination multiple arch and gravity structure near Bergamo, Italy, failed Dec. 1, 1923, following heavy rains. The dam was 143 ft. high above the stream, 863 ft. long, of which 250 ft. was a central curved portion, the remainder being straight end tangents. The central part, which failed, had a gravity base of stone masonry surmounted by multiple arches of reinforced concrete. In all there were 25 arches, nine of which fell. Unusually poor construction was the main cause. Lime mortar in the base masonry, poor concrete with unwashed aggregate in the superstructure and extremely poor reinforcing in the buttresses were typical features. The rock foundation had a natural slope downstream and had not been leveled, stepped or notched before building the masonry base block. Six hundred persons lost their lives.

Moyie River Dam—A thin concrete arch structure in Idaho failed in 1925. The dam was 154 ft. long, 53 ft. high, of which 6 ft. was in a cutoff trench, and varied from 64 to 24 ft. thick. The spillway was undermined, after which the flood waters cut a deep bypass around the end of the dam, carrying out one of the abutments. Outside of the complete destruction of the abutment, the dam remained intact. A soft and stratified rock under part of the spillway contributed greatly to the undermining.

Lake Lanier Dam—A thin concrete arch structure in Tryon, N. C., failed Jan. 21, 1926. It was 236 ft. long, 62 ft. high from bedrock to top of spillway, with a 5-ft. cutoff wall. It was reinforced only in the upper 12 ft. and by anchors in the cutoff wall. It failed through the washing out of one of the cyclopean masonry abutments which had been founded on soft and decomposed rock. The rest of the dam stood.

Dolgarrog Dam—Gravity concrete structure in North Wales failed Nov. 2, 1926. The dam was 3,300 ft. long, about 20 ft. high with footings extended 18 in. into clay. Failure consisted in the scouring out of a 30-ft. section of clay underlying the footing. Water from this opening caused the overtopping of an earth dam further down stream, which resulted in the drowning of sixteen persons. Poor foundation and poor concrete were features of the case.

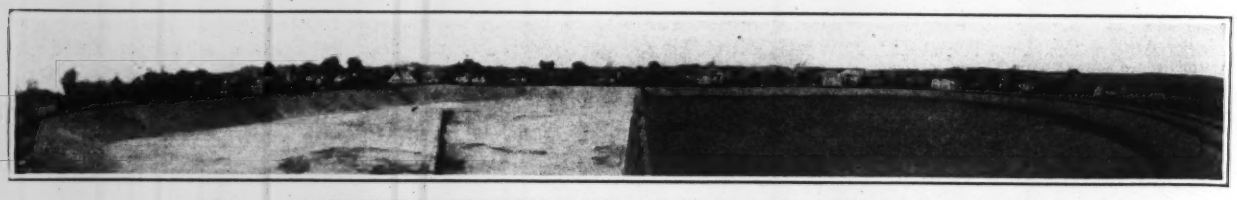


FIG. 1—CAMBRIDGE WATER RESERVOIR MADE TIGHT BY A2-IN. GUNITE LINING
Left half of reservoir has been completed with 2 in. of gunite on floor and slope. Note on right side the granite slab slope paving which had to be covered. The reservoir capacity is 43,000,000 gal., and the leakage was 500,000 gal. daily when relining was begun.

Guniting Methods and Experiences at Cambridge Reservoir

Sand Conditions Affect Precise Proportioning—Daily Output and Lost Time Records of Four Guns for 30 Days—Skill of Gunman and Nozzleman Determines Quality

By Charles E. Price
Engineer, Providence, R. I.

MUCH has been written about the cement gun, but very little about its operation. This article gives facts and figures that were secured by the writer while acting as senior inspector on the repairs of the Payson Park Reservoir, Cambridge, Mass., under the supervision of Lewis M. Hastings, city engineer.

The Work Done—The reservoir consists of two basins having a capacity of 43,000,000 gal. and was built 30 years ago. The floor of each basin is concrete; the slopes are brick and granite. The brick, laid up in cement mortar, covers about 15 ft. on the average of the lower section of the slope; the granite slabs, laid on broken stone, with open joints, complete the slope to the rim.

During the past few years a loss of water has been noted. On June 1, 1927, it had reached 500,000 gal. in 24 hours. After investigating numerous methods of making reservoirs watertight, gunite was decided upon A contract was awarded to the Rust Engineering Com pany, of Pittsburgh, Pa., at $131,000. The approximate quantities of gunite were 245,700 sq.ft. of floor, 39,510 sq.ft. of brick slope, 65,160 sq.ft. of granite slope and 23,013 sq.ft. on the two faces and berms of the dividing wall, making a total of 373,383 sq.ft. to be covered to an average minimum thickness of 2 in. About 6 in. of 1 : 2½ : 4 concrete was placed on the floor of the south basin before any gunite was applied. The floor of the north basin was in such good condition that no additional concrete was required. The guniting was started on Aug. 22 and was completed on Dec. 6, 1927, a total of 107 days, including holidays and Sundays.

Compressor Capacity Required—One 600-cu.ft. compressor and two compressors of 300 cu.ft. each were linked up into one unit furnishing 1,200 cu.ft. of air per minute through a 3-in. pipe a maximum distance of 700 ft. An attempt to operate four guns of the N-2 size with this equipment was not successful. An additional 300-cu.ft. compressor was installed, from which one of the four guns was operated. The average daily pressure at the tank supplied by the three units furnishing the 1,200 cu.ft. of air was less than 50 lb. Frequently with this pressure there was not enough air to operate three guns satisfactorily; a nozzle velocity corresponding to an air pressure at the gun of not less than 35 lb. per sq.in. is required for the application of hard and dense gunite. It would seem reasonable to suppose that 1,500 cu.ft. of air would be sufficient to operate four guns and a few drills, but it was not. It was necessary to install an additional compressor of 118-cu.ft. capacity, with a maximum pressure of 125 lb., to operate the drills for the anchor-bolt holes in the floor and brick slopes.

Continuous Mixer Operation—A continuous mixer was used, and it required continuous inspection if satisfactory results were to be obtained. Checks made hourly showed that "green" cement, old cement, and wet, medium and dry sands all affected the proportions to a very marked degree. Failure to keep the hoppers full operated to change the mix from 25 to 50 per cent. A change from first to second and third speeds, with a mixture of 1 part cement to 2½ parts of sand, required a change in the adjustment of the blade in the cement hopper.

To illustrate, assume that the machine is running in third speed with "green" cement and with sand having a moisture content of 5 per cent. The blade in the cement hopper is set at 8 on the indicator for a 1 to 2½ mix. Increase the moisture content in the sand and the blade in the cement hopper will have to be moved to 8¾ or 9 on the indicator, which means that an increased volume of cement is necessary to maintain the same ratio of 1 to 2½. Checks made by the inundation method showed conclusively that in any given period of time more moist sand than dry sand was discharged by this machine operating on third speed.

A few of the results obtained while operating the mixer at third speed and set at 8¾ on the cement dial are given in Table I. To operate at this speed required four men wheeling sand, two men bringing cement to the platform, one man opening the cement sacks and one man feeding the cement hopper. When old cement is used, a screen should be used in the cement hopper to prevent the accumulation of lumps. One small lump at the discharge opening of the cement hopper will decrease the cement content of the mix as much as 20 per cent.

Yardage Per Bag of Cement—Inquiry from several contractors and engineers who had had experience with the cement gun disclosed that there was a wide difference in the yardage obtained per bag of cement. This for a 1 to 2½ mix varied from 10 to 15 sq.ft. for a thickness of 2 in A careful record was kept of each day's run on

TABLE I.—ACCURACY OF PROPORTIONS SECURED WITH CONTINUOUS MIXER FOR CEMENT GUN WORK

Sand, Cu.Ft.	Moisture Allowance, Per Cent	Volume Dry Sand, Cu.Ft.	Cement Used, Bags	Proportion, 1 to
62.10	12.0	54.65	21	2.60
60.00	12.0	52.80	22	2.40
118.00	15.0	100.30	40	2.51
93.00	10.0	83.70	34	2.46
81.90	10.0	73.71	29	2.54
66.60	10.0	59.94	24	2.50
63.90	10.0	57.51	24	2.40
70.29	10.0	63.26	25	2.53
69.90	10.0	63.00	24	2.62
69.00	10.0	62.10	24	2.60
85.75	10.0	78.98	31	2.55
95.16	10.0	85.64	32	2.67
48.80	17.7	40.16	15	2.67
92.13	17.7	82.30	29	2.60
73.20	17.7	60.54	24	2.52
65.07	17.7	53.55	20	2.67
65.88	17.7	54.22	22	2.47
				2.55
Tests on third speed set at 8¼ on dial showed				2.72
Tests on third speed set at 8 on dial showed				2.88

Note:—The above results were obtained only by rigid inspection, frequent checks, and keeping the hoppers full at all times.

this job. Table II shows the average number of square feet of gunite shot per day, the cement used, the number of square feet of 2-in. gunite per bag of cement, and the wide variation in the amount produced by the several guns based on a 9½-hour day. In fairness to the cement gun, it should be stated that the loss in efficiency, 31 to 44.6 per cent, is excessive, and should not exceed 10 per cent.

Experienced Operation Required—None but experienced gunmen and nozzlemen should be permitted on

FIG. 2—FLOOR REINFORCEMENT AND GUNITE COVERING

any job where quality and efficiency are desired. There were several local men who were broken in on the job and did some very excellent work under normal conditions, but they were helpless with the nozzle and with the operation of the gun when conditions were against them. If a nozzleman is expected to shoot an even surface he must have a man operating who understands the machine and feeds the material to the nozzleman uniformly.

The amount of material that can be passed through a gun in a day depends upon the care with which the material is handled. Increase in the moisture content of from 5 to 18 per cent in the sand will decrease the number of square feet of 2-in. gunite that can be shot per hour, as shown by the following figures: 387, 370, 298, 286, 264, 230, 230, 230, 205; total 2,500 sq.ft. Note the decrease in the number of square feet per hour, with the same gun and no lost time, with the increase in moisture content. This same gun crew, with the sand running uniform in moisture, made a record of 3,047 sq.ft. in eight gun-hours and a record for three consecutive days of 7,595 sq.ft. in 26¾ gun-hours. The record for a single day's shooting, with four guns operating 34½ gun-hours out of a possible 40 hours, was 7,535 sq.ft.

From the figures it will be noted that one gunman furnished his nozzleman on three consecutive days (26¾ hours) more material than four guns (34½ hours) supplied in any single day. The answer is: Employ only experienced gunmen and nozzlemen and keep the moisture content in the sand down to less than 10 per cent. It is quite evident from the figures that four guns operated by experienced gunmen and nozzlemen, with lost time for all causes cut to 10 per cent, could have shot 10,000 sq.ft. of 2-in. gunite per day.

Guniting Floors—In applying gunite to floor areas which adjoin slopes or perpendicular walls, the best practice is to shoot at least 3 or 4 ft. of slope or wall integrally with the floor. This method avoids bad laps and joints at the point where the wall and floor meet, because the sand rebound from the shooting will fall below the point where the lap is to be made.

Guniting Walls—Very excellent results were secured by shooting the dividing wall from the bottom up. The reinforcing mesh was at all times free and clear of all rebound and no time was lost in washing down or cleaning up the wall areas. A section of wall to which gunite was to be immediately applied was sandblasted to remove fungus and vegetable growth, and then thoroughly washed with a jet of water and compressed air. After this operation was completed the application of gunite proceeded without interruption until the entire section from the bottom to the top was finished. By actual measurement, the loss in rebound on the wall areas was 25 per cent, with an average surface area covered of 1,000 sq.ft. per day of eight gun-hours.

Tests for Thickness—Each nozzleman was provided with an assistant whose duty it was to move the hose, to

TABLE II.—CEMENT GUN PERFORMANCE FOR ONE MONTH

Daily Run of Guns; 30 Days								Total	Bags Cement	Sq.Ft. Per Bag
Gun A		Gun B		Gun C		Gun D				
Sq.Ft.	Hr.	Sq.Ft.	Hr.	Sq.Ft.	Hr.	Sq.Ft.	Hr.	Sq.Ft.	Used	Cement
2,856	6¾	1,344	4	....	..	....	..	4,200	319	13.2
1,400	7½	1,840	8	1,582	8	....	..	4,822	408	11.8
1,256	6½	2,535	8½	1,067	4½	....	..	4,858	436	11.1
1,700	9	2,500	9½	1,561	8¾	....	..	5,761	511	11.3
1,700	8	2,560	9¼	1,541	8	1,387	8¼	7,188	592	12.1
1,651	8	1,359	7	1,343	7¼	1,475	8	5,828	541	10.8
1,915	8½	2,184	8½	1,937	9½	1,499	8¼	7,535	682	11.1
1,060	7	2,519	7¼	1,125	7¼	1,352	7¼	6,056	551	11.0
1,432	7½	2,117	6¼	1,572	7½	1,931	7½	7,052	619	11.4
1,287	8	3,047	8	1,450	8½	840	8½	6,634	614	10.8
2,090	8½	2,207	7	2,394	8½	....	..	6,691	625	10.7
1,297	8½	949	4½	1,677	8½	1,326	6½	5,249	537	9.8
1,400	7	2,407	8	1,677	7	1,097	7½	6,581	633	10.4
1,617	6¾	2,121	7	1,611	6½	1,086	6¾	5,435	590	10.9
1,748	6	....	..	1,748	6½	750	6½	4,247	328	12.9
....	..	700	3½	978	3½	556	3½	2,234	221	10.1
1,586	6½	972	5	1,600	7	1,209	6	5,356	408	13.1
758	6	575	6¼	1,100	6½	1,292	5½	3,725	316	11.8
2,000	7	1,200	7	2,007	7	1,157	7	6,364	486	13.1
1,595	5	1,241	6½	2,183	7¼	1,247	6¾	6,266	557	11.3
1,800	6½	1,270	6½	1,170	5½	1,389	6½	5,629	497	11.4
2,175	6¾	1,362	6¾	....	..	1,767	5¾	5,304	527	10.1
2,456	9¾	1,073	6	....	..	2,118	8¾	5,647	551	10.3
2,551	7¼	1,190	6¼	....	..	2,237	6¾	5,978	555	10.8
2,540	7¼	1,507	8¼	....	..	2,220	7¼	6,267	610	10.3
1,647	5	425	2¼	....	..	1,907	5	3,979	326	12.2
1,860	7¼	1,388	7¼	2,200	7	....	..	5,448	443	12.3
2,200	7¼	1,786	7¼	2,204	7¼	....	..	6,190	545	11.4
....	..	1,292	7	2,698	7	2,786	7	6,776	493	13.7
....	..	1,448	6	1,050	6	2,393	6¾	4,891	476	10.3
Averages										
1,762	..	1,625	..	1,645	..	1,522	..	5,640	500	11.3
	7.26		6.73		7.07		6.86	Av. gun-hr. per day.		

The above figures are for a period of 30 days beginning Oct. 23, 1927. The average work day was 9¼ hours. A gun to give 100 per cent efficiency would therefore operate 285 hours.

Gun	Hours Operated	Per Cent Efficient	Time Lost, Per Cent
A	196	68.8	31.2
B	195	68.4	31.6
C	170	60.0	40.0
D	158	55.4	44.6

Part of the time the small type gun N1 was operated by both B and D gunmen. The figures are not affected, however, as the results for the first five days operated by D gunman showed an average of 1,530 sq.ft. per day of eight hours' actual shooting.

lift the wire mesh with a hook so that the wire was properly embedded in the gunite, and to gage the thickness of the gunite with a needle. This needle was 2 in. long and was attached to the end of a tapered rod. As the nozzleman applied the gunite, his assistant would test it frequently with the needle and, where it lacked 2 in., would scratch the surface and the nozzleman would then build up until the required thickness was secured. Soft iron wire was used for needles, as it was found that steel needles were too easily broken through careless use. Check on the length of the needles was made daily at the start of the work.

Guniting Slopes—A check on the placing of 42,446 sq.ft. of gunite on the granite and brick slope-paving showed an average of 195 sq.ft. per gun-hour, or a total

FIG. 3—CEMENT GUN OUTFIT WORKING ON FLOOR

of 1,415 sq.ft. per day of 7¼ gun-hours. Considerable time was required to clean the granite slope in preparation for shooting. The accumulation of earth and vegetable growth required the use of steel rods to loosen the material, after which it was blown out with compressed air and washed thoroughly with a jet of water at about 60-lb. pressure.

Reinforcement—Electrically welded No. 5 galvanized steel wire mesh, with wires spaced 4 in. apart in both directions and weighing about 71 lb. per 100 sq.ft., made up in sheets 8 ft. wide and 100 ft. long, was used. By cutting these sheets into 50-ft. lengths they were easily handled and placed on the slopes at minimum cost. The sides and ends were lapped not less than 4 in. and securely tied at intervals of not more than 18 in. with No. 14 black iron wire ties. On the top edge of the granite paving the sod was carefully rolled back and the earth excavated to a depth of about 1 ft. The mesh was then bent over the stone rim to a width of about 8 in. and securely tied to the stone with ⅝-in. galvanized-iron anchor bolts at intervals of not more than 3 ft. On the face of the stone slope paving the mesh was tied to ⅝x5-in. galvanized-iron lag screws which were wedged into the joints of the granite paving. On the brick slope the mesh was securely tied to ⅜x4-in. galvanized-iron expansion bolts.

The gunite was applied in the following manner: The top edge or rim was given a coat not less than 2 in. thick for a distance of from 30 to 75 ft., depending upon conditions and the number of men operating nozzles. Then 6-ft. planks were placed on the slope down about 7 ft. from the top edge, and the shooting of the slope proceeded. The contract called for the filling of all holes and cracks with gunite and in addition an application of a minimum thickness of 2 in. of gunite.

Where specifications call for the filling of holes and cracks, the engineer or inspector should see to it that the nozzleman uses a sufficiently plastic mixture to permit it to enter the crack or hole. An expert nozzleman can, by clever manipulation of the nozzle and by cutting the water content, bridge a hole 3 to 4 in. in diameter without shooting any considerable material into the hole.

Water Curing—This contract called for covering the gunite with burlap kept wetted for a period of not less than 96 hours. It is strongly recommended that this feature be strictly adhered to and that not one square foot of gunite be shot until sufficient burlap is on the job to cover at least four days' work and the water supply lines are laid and tested. All gunite should be thoroughly saturated with water for at least 96 hours. Insist on water or shut down the job.

Sand Rebound—The loss of sand in shooting the slopes was between 12 and 15 per cent; the loss on the perpendicular dividing wall was 25 per cent. There is con-

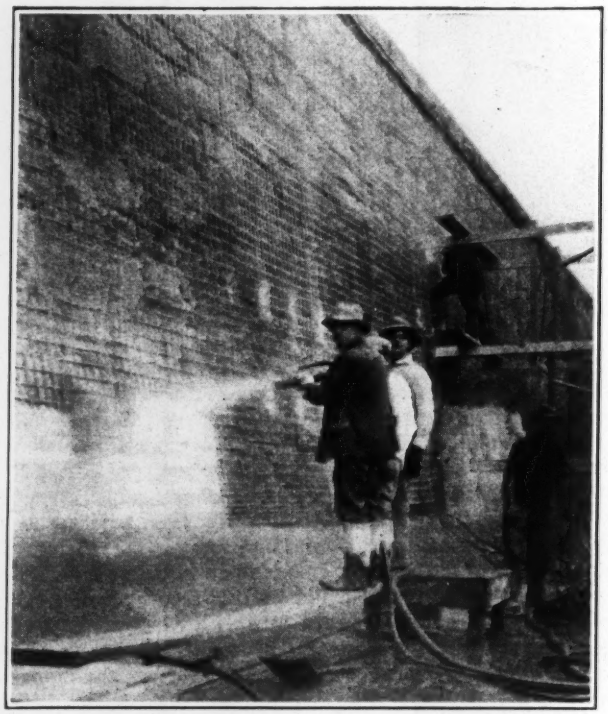


FIG. 4—GUNITING BRICK PARTITION WALL

siderable difference of opinion concerning the incorporation of the sand rebound when shooting gunite on the floor. Here again is where an experienced nozzleman is to be desired. An experienced man will not permit the sand to accumulate but will incorporate it as he is shooting. A practice to be condemned is to permit the sand

rebound to become ¼ to ⅜ in. deep and then shoot wet gunite into this sand, mixing it into a soupy mass and building up to the 2-in. thickness with a proper gunite mixture. The result of ths procedure is a weak porous mixture on the bottom and ofttimes a layer of sand devoid of cement coating. The best practice and the safest method is to stop the motor of the gun and with the air pressure blow this rebound away if a first-class job is desired. This requires only a minute or two at the most, as it is not usually necessary to shift the hose to the air line to blow material away.

Shooting Into Water—Gunite does not approximate the proper density when shot into a pool of water.

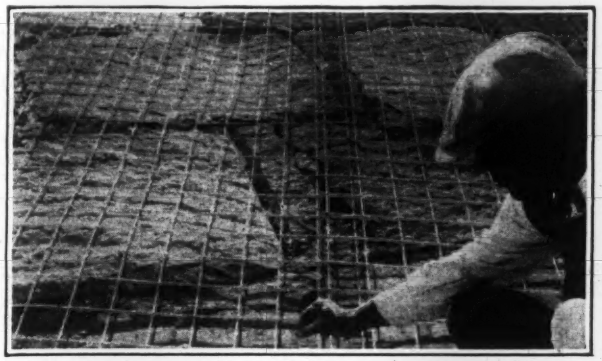


FIG. 5—REINFORCEMENT ON GRANITE PAVING READY FOR GUNITE

Shooting dry material into water and depending upon it to produce gunite should not be permitted. An examination of material shot in this way will reveal a lack of homogeneity, with varying conditions of density and porosity. In case of heavy rains resulting in the flooding of any area, it is better to lose a day while draining off the water than to permit shooting into pools of water.

Hose for Guniting—The use of first-quality high-pressure hose and proper hose connections will eliminate to a very large degree the pooling of water. The bursting of hose or the breaking of hose connections ordinarily requires a shutdown of from ten to fifteen minutes for repairs. This means that a nozzleman, his assistant, a gunman and a shoveler must remain idle, besides the loss in the day's run of from 60 to 75 sq.ft. of gunite, each time trouble is experienced with cheap hose. A daily check on the job kept by the writer showed a loss per day of approximately one hour, or four man-hours—that is, $2.40 per day, or $72 per month, with corresponding gunite loss of more than 9,000 sq.ft.

Freezing Temperatures—The shooting of gunite in reservoir construction at freezing temperatures is too expensive and the progress is necessarily slow. A small amount of gunite was shot on this job in the month of December, under canvas with the use of salamanders, with satisfactory results but at too great cost. The rule followed was not to start operations until the temperature was at 36 deg. and on the rise. Work would stop when the temperature fell below 38 and the gunite was covered with about a foot of straw and tarpaulins to protect it against freezing. Great care should be taken when working at low temperatures to see that no frost exists in the old gunite to which new gunite is to be bonded. This requires warming up the surface by any of the various means employed in winter building construction to prepare cold concrete surfaces to receive warm concrete.

Changes in Rail-Mill Practice

AS REPORTED by the committee on rail at the annual convention of the American Railway Engineering Association March 6-8, there has been a marked increase in the demand for heavier rails, particularly within the last five years. The percentage of rails of 100 lb. per yard or heavier to the total rail production increased from 28 in 1920 to 61 per cent in 1926. Increased weight, combined with the almost universal adoption of the 39-ft. standard length, has affected rail-handling methods in the finishing mill and back as far as the open-hearth department.

In the open-hearth departments, changes have been made in furnace construction as to width, length, shape of roof and back wall, as well as changes in design of the ports at either end, increasing the efficiency of combustion, mixing and flame action to effect more thorough refinement in the bath. Tar and oil have been used in some furnaces to increase the intensity and sharpness of the flame action and decrease the sulphur carried into the bath. The work at the pouring platform at some mills has been improved by coating the interior of the molds with both graphite and tar, which prevent the spattering particles of molten metal from adhering to the sides of the mold, and create much smoother ingot surfaces for easier rolling conditions.

Increase in percentage of silicon has reduced or eliminated the necessity of "killing" the steel in the molds with aluminum, and its use has now been discontinued at several plants. Stopper rods and nozzles for ladles have received considerable attention, and improvements have been made in the type and materials used to reduce the likelihood of spattering or leaking and running stoppers when filling the ingot molds.

Some mills have introduced changes in the shape and size of ingot molds, particularly wall thickness and cross-section at the bottom compared with the top, and have increased the radii at the corners to prevent cracking of the molds and shortening their life, and have thus reduced the possibility of weakness in the corners of the cast ingots. "Hot top" molds were also used on sizable experimental tonnages by three different roads independently. The purpose of these tests was to determine what effect this type of mold has on the various processes involved in rail manufacture and to determine the relative quality of the material compared with that made in standard ingot molds. The rails are now in service and at some later date interesting test data may be available.

The practice of duplexing steel by the rapid conversion of bessemer into open-hearth has been abandoned by most of the rail mills, and the open-hearth furnaces in these installations have now been converted for standard open-hearth heats.

Changes have been made in both the type and the composition of the rolls used at some of the rail mills for the purpose of increasing their life and usefulness, of reducing roll failures and, by reducing the wear on the roll, of obtaining rail sections which are closer to template. The desirable practice of wash heating the blooms after the ingot has been reduced to bloom size, and before rolling into rails, has been extended. One mill is rebuilding its plant and incorporating reheating furnaces for this purpose.

A decided improvement has taken place in the hot sawing of rails at several rail mills. Experiments were made

with various types and thicknesses of saws so that the end faces of the cross-sections would not contain objectionable and deep ridges but would be practically square and reduce the saw burr. Automatic and adjustable curving or cambering rolls have been installed and are proving of great value in eliminating drag and blurring of the burr from the hot saw cut. The result is that a much smoother and more even finish is secured on the rail ends.

The practice of spacing of rails on the hotbeds to promote uniform cooling is now being followed by several of the rail mills and has resulted in a noticeably smoother rail at the straightening presses and a reduction in the amount of gagging required to straighten rails. The equipment for handling rails on the hotbed is rather elaborate at some mills, while the rails are being spaced largely by hand at other plants. The arduous work of handling long and heavy rails in the straightening presses has caused some mills to devise and install mechanical devices for rotating rails into position under the presses. Preliminary trials have also been made with roller straighteners to determine the advantages and possibilities of the use of this practice, which is general in the European rail mills.

The classification of rails as to quality, fitness and chemistry, as well as lengths, as outlined in the A.R.E.A. and other specifications, has necessitated remodeling of the finishing mills and handling facilities at many rail plants. The change from the 33- to 39-ft. standard length required the expenditure of several million dollars in the aggregate for all of the rail mills. Economic conditions have recently required one rail mill in the Eastern district to rebuild and enlarge its facilities at the cost of several million dollars, and in particular to meet the demands for heavier and longer rails.

As to the use of different grades of steel, there has been a considerable increase in the demand for intermediate or medium manganese, which is a steel of promising superiority over the standard open-hearth composition. Experimental lots of heat-treated rails have recently been installed on five different railroads on sharp curves in heavy traffic territory. Cumulative data are being secured of the relation of cost, physical characteristics and wear compared with standard untreated rails. There has been more activity in experiments on heat-treated rails during the past year than for a great many years, and the experiments are being observed in a number of different places.

Mild Weather Aids New Jersey Engineers in Keeping Water-Flow Records

Extremely mild weather and high water conditions throughout New Jersey during the present winter have been a distinct advantage to the state's hydraulic engineers in their work of keeping a continuous record of the flow of water in the streams of the state, according to the Division of Waters, of the New Jersey Department of Conservation and Development. During normal winter weather, with streams and ponds frozen over, stream gaging is difficult, as ice interferes with the operation of the automatic water level recorders and continuous checking by the hydraulic engineers is necessary to preserve an accurate continuous record of the flow of water in the stream.

These records are used in estimating the possibilities of a stream for future water supply and water power.

Activated-Sludge Plant for Wahiawa, Hawaii

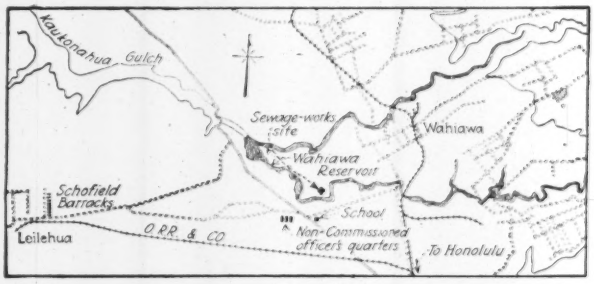
Town Located Between Two Arms of Irrigation Reservoir Requires Complete Sewage Treatment, Including Chlorination

By F. M. Veatch
Of Black & Veatch, Consulting Engineers, Kansas City, Mo.

A More Up-to-Date Sewage-Works than the one being constructed for the far-away town of Wahiawa, near Honolulu, would be hard to find. To meet local conditions, a high degree of treatment is required. To that end the activated-sludge process will be used and at times the final effluent will be chlorinated. Gas from the Imhoff tanks will be collected. The sludge-drying beds will be under glass. —Editor.

THERE is now under construction a sewage-works of the activated-sludge type for Wahiawa, a town of approximately 3,000 persons, located on the island of Oahu, about 23 miles inland from the City of Honolulu, Hawaii.

Wahiawa is located on a peninsula between the two arms of the impounding reservoir of the Wahiawa Water Company, formed by a dam in the Kaukonahua stream just below the junction of its north and south forks. This reservoir is used for storing water for irrigation only, since the domestic water supplies for Wahiawa and for Schofield Barracks are taken from the north and south branches of the stream at intakes located well above high water in the reservoir. The territory around Wahiawa is devoted almost entirely to pineapple raising and is fairly thickly populated. A large school is located within 1,300 ft. of the only feasible disposal plant site, and the non-commissioned officers' quarters of Schofield

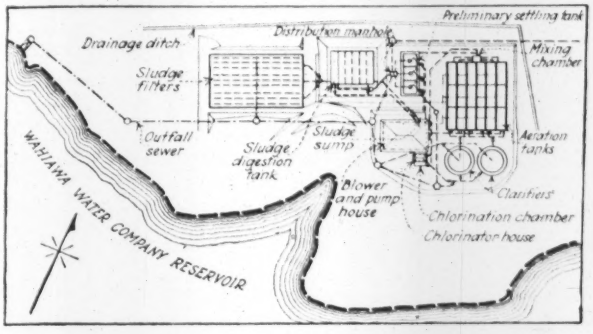


LOCATION OF WAHIAWA SEWAGE-WORKS

Barracks, the largest military post of the U. S. Army, lies within 1,800 ft. of it. The sewage-disposal problem is therefore complicated both by the lack of an isolated plant site near the town and by the fact that the sewage must either receive complete treatment in an inoffensive plant and be discharged into the reservoir or be carried 10,000 ft. to a point below the dam where an isolated site is available. The reservoir is very deep, the gulch through which the stream flows is very narrow and the construction cost of an outfall line to a suitable disposal plant site below the dam is too high for consideration. Complete treatment is required regardless of the outfall location, since the stream flow below the dam is negligible for part of the year.

The climate of Wahiawa is warm and humid. The average monthly summer temperature varies from 60 to

87 deg. F. The annual rainfall ranges from 25 to 65 in., but at higher altitudes on the watershed of the Kaukonahua stream the rainfall is from 50 to 250 in. per year. For the ten-year period ended Dec. 31, 1926, rain fell on 53 per cent of the days. The average period without rain was three days, although six times in the ten years rainless periods longer than ten days were recorded. Sunshine during 1926 was 46 per cent of that possible for the year and ranged from 34 per cent in November to 61 per cent in July. Relative humidity during the winter months ranges from 90 to 95 per cent at midnight to 70 to 85 per cent in the afternoon. During the summer it varies from midnight values of 80 to 85 per cent to afternoon values of 60 to 65 per cent. The temperature of the water supply ranges from 70 to 75 deg. F. throughout the year and that of the sewage will be approximately the same. These climatic conditions, coupled with the relatively high and even temperature of the sewage, favor rapid sludge digestion and efficient oxidation, but the high humidity and lack of sunshine make impractical the drying of sludge in the ordinary open sludge bed.



GENERAL PLAN OF ACTIVATED-SLUDGE PLANT FOR WAHIAWA, HAWAII

Wahiawa has had a rapid growth since 1920, due principally to the development of the pineapple industry and to a less extent to the maintenance of a large garrison at Schofield Barracks. The town is within commuting distance of Honolulu, and since it is approximately 1,000 ft. higher and noticeably cooler than the city, it is being used to some extent as a residence location.

The sewage-works was designed to serve 6,000 persons, the probable population of Wahiawa in 1937, but as the sewers and sewage-works will be built under the same contract, some time will elapse before the entire present population will be served; therefore the plant has been designed with a relatively large number of small units, to allow it to operate as nearly as possible at normal rates until the expected flow of sewage is realized. The activated-sludge process was chosen because space is not available for sand filters, and the operation of a sprinkling filter at the only available site would be intolerable on account of odors.

The average per capita sewage flow has been estimated at 100 gal. per day, a rather low figure for the islands, where sewage flows of 250 to 300 gal. per capita per day are the rule. These high rates are due largely to excessive use of water and to ground-water seepage, factors that will not be encountered at Wahiawa, where the water supply is carefully conserved, where the services are 100 per cent metered and where the sewers will be entirely above the ground-water level. The maximum daily flow is estimated at twice the average rate, or 150 gal. per capita per day.

The disposal plant will consist of plain settling tanks, aeration tanks, final settling tanks to be equipped with mechanical devices for sludge removal, sludge digestion tank, glass-covered sludge-drying beds, chlorination tank and a building for blowers and sludge-pumping equipment. The preliminary settling tanks are designed for a detention period of 30 minutes at the maximum rate of flow, and three units of the hopper-bottomed type, 12 ft. square and 16 ft. deep, will be provided. The sewage will enter the tanks through submerged inlet pipes that terminate near the center of each tank, and will be drawn off over weirs that extend the full length of the tank walls. The effluent will be collected in a flume girdling the three tanks and will be delivered to the mixing chamber of the aeration tanks through a 12-in. pipe. The sludge will be siphoned off through three ordinary sludge-eduction pipes to a sump, from which it will be pumped to the digestion tank.

Six aeration tanks, each 64 ft. long, 8½ ft. wide and 8 ft. deep, will be constructed, with a total capacity of 0.18 m.g. or six hours' average flow plus 20 per cent returned sludge. Each tank will be connected to the mixing chamber by an 8-in. submerged inlet pipe, provided with a sluice gate, and the effluent will be drawn off into either or both of two final settling tanks. A single row of filtros plates in precast concrete containers will be set along the bottom of each aeration tank, approximately 18 in. from one of the walls. Each row will contain six plate containers which hold nine 12x12-in. plates, a total of 54 sq.ft., or very nearly 10 per cent of the tank surface. Air will be supplied through three 4-in. cast-iron headers, each of which serves twelve plate containers, or 108 sq.ft. of plate area, through six 3-in. drop pipes. The aeration tank bottoms are shaped with concrete fillets to give a spiral motion to the sewage as it flows through the tank. To prevent any possibility of short circuiting, two division walls, with ports 3 ft. square, are located in each tank.

The mixing tank in which the return sludge from the final settling tanks is mixed with the settled sewage will be provided with filtros plates to enable air to be used for agitation.

Two final settling tanks, 20 ft. in diameter, with a combined capacity of 36,000 gal., or 1.2 hours' average flow plus 20 per cent returned sludge, will be provided. Mechanical clarifier equipment of the Dorr type for continuous sludge removal will be installed and sludge will be pumped by a motor-driven diaphragm pump connected direct to the sludge outlets. The aerated sewage will enter the tanks at the center and will be drawn off, over weirs on the circumference, into flumes that discharge either into the outfall or into the chlorination tank.

At low-water stages in the reservoir the aerated and settled sewage will be sterilized with liquid chlorine. For this purpose a baffled, hopper-bottomed tank, with a capacity of 15 minutes' flow, will be provided. A small building to house the chlorine supply and dosing equipment will be constructed over this tank, and a weir with a recording water-level gage will be set at the outlet end to enable a continuous record of the sewage flow to be kept. Sludge from the chlorination tank will be drained by gravity to the sludge sump.

A sludge-digestion tank with a capacity of 12,960 cu.ft., or slightly more than 2 cu.ft. per capita, will be constructed. This tank will be divided by baffles into six

compartments, each 6x30 ft. in plan, so connected that the total length of travel from the inlet to the outlet will be approximately 200 ft. A concrete cover with a central gas-collection dome will be provided. To prevent the scum from drying out and caking, the water level in the tank will be maintained from 1 to 6 in. above the lower surface of the cover. The excess activated sludge and fresh sludge from the preliminary settling tanks will be pumped into the digestion tank near the surface of the first compartment, and the digested sludge will be siphoned from the lower part of the last compartment to the sludge beds. The overflow from the sludge digestion tank will be taken off near the surface of the last compartment and returned to the preliminary settling tanks for re-treatment. Provision has been made for circulating the digesting sludge by pumping, and for adjusting the pH value by the use of lime when this is necessary.

Sludge-drying beds with a total area of 4,000 sq.ft., or ⅔ sq.ft. per capita, will be provided, inclosed in a standard greenhouse structure. The beds will be 15 ft. wide and will be separated by 2-ft. walks to facilitate the removal of dried sludge. Ports have been provided at the end of each bed just above the sludge level and motor-driven exhaust fans will be placed at the opposite ends to secure a draft over the sludge while drying.

The activated sludge will be pumped direct from the clarifiers to the mixing chamber of the aeration tanks, or to the sludge digester, by a motor-driven diaphragm pump with a maximum capacity of 50 gal. per minute against a head of 25 ft. The raw sludge from the settling tanks, together with other drainage from the plant, will be collected in the sludge sump and pumped into the digestion tank or into the preliminary settling tanks by a motor-driven centrifugal pump with a capacity of 250 gal. per minute against a head of 25 ft. Both of these pumps are located in the blower house, the former on the operating floor level and the latter in a pit.

Air under a pressure of 4 lb. will be provided by three motor-driven rotary blowers with capacities of 100, 200 and 300 cu.ft. per minute or in terms of sewage flow 0.25, 0.50 and 0.75 cu.ft. of air per gallon of sewage. A gasoline engine-driven generator set will be installed to provide power for the blowers, pumps and clarifier equipment in emergencies.

A contract for the construction of this plant was let on Nov. 7, 1926, to Ralph E. Woolley, of Honolulu, for $96,130, to be completed in six months. Plans and specifications were prepared by Black & Veatch, Kansas City, Mo., and Los Angeles, Calif., and the construction work is under the supervision of H. A. R. Austin, chief engineer, Department of Public Works, Honolulu, Hawaii.

Funds Provided for Study of Salt in Irrigation

The agricultural appropriation bill passed by the House of Representatives on March 3 provides an increase of $33,000 for the next fiscal year to be devoted to fundamental investigations concerning salt problems in relation to irrigation. This work will be under the direction of the office of Western irrigation agriculture of the Bureau of Plant Industry, Department of Agriculture, of which C. S. Scofield is in charge.

This appropriation is a recognition of the menace of salt accumulation in irrigated land, due to excess of salt inflow over the outflow in drainage water. It is in line with suggestions made editorially by *Engineering News-Record.*

Concrete Ties Twenty Years in Track

Composite Ties of Concrete and Steel Made Good for Further Service in Track by Minor Repairs

SOME reinforced-concrete ties that have been in the high-speed heavy-service main track of the Pennsylvania Railroad for nearly twenty years have been repaired successfully, patches of crushed or disintegrated concrete being replaced so that the repaired ties are practically as good as when new. Seven ties were thus repaired during 1927 and replaced in track. At the same time new tie-plates were applied to replace those that had buckled under the heavy wheel loads, and new bolts were inserted for the rail clips. In the repair work the broken parts of the concrete were removed and the rough surfaces of these pockets cleaned. New concrete

CONCRETE TIES BEING REPAIRED

was then rammed into place and troweled to a smooth surface, and was found to make a satisfactory bond with the old concrete. Some of the repaired ties are shown in the accompanying illustration. Except for the bending of the tie-plates under present-day loading and minor crushing, these ties are still sound.

These ties, designed by L. J. Riegler, assistant engineer of the Pennsylvania Railroad, consist of a concrete body reinforced by rods and having on each side a steel plate bent to form a channel with convex web, approximating the shape of a wood tie with rounded sides. The top and bottom flanges of the channels are connected by riveted straps across the ends and middle of the tie. Lugs stamped inward from the channel webs form a bond with the concrete. In section the tie is 7 in. thick, 9⅜ in. wide at top and bottom and 12 in. at mid-depth, with a weight of about 850 lb.; it can be used with either side up. The ties are handled usually by the trackmen. The rails rest on flat steel tie-plates, and each rail is secured by clips and nuts on four bolts, the heads of which lie in pockets formed in the bottom of the tie. Originally the ties were put under 85-lb. rails, which were later replaced by 100-lb. and subsequently by 130-lb. rails.

There are fifteen of these ties, all of which were laid in May, 1908. They are on a 33-ft. rail length of main track carrying about 35 trains daily. They cause no trouble with the track circuit, and this piece of track is said to require considerably less maintenance work and cost than the adjacent track having eighteen treated wood ties to the rail length.

Concrete Testing Pointed Toward Construction Problems

A.C.I. Papers Record Studies of Crazing, Hair Cracking, Dusting, Concrete Flow, Bar Anchors and Field Beam Tests Which Hold Practical Interest to Contractors

TESTS designed to advance working procedure in concrete construction were a notable activity of the American Concrete Institute in 1927. This fact lent a decided laboratory tone to the papers and discussions at the annual meeting at Philadelphia the first week in March, as reported in *Engineering News-Record*, March 8, 1928, p. 408. In general, however, the test studies were directed to the solution of practical working problems and so they assume an interest to the contractor and construction engineer as well as to the concrete technologist.

In the group of six papers abstracted here four are of direct and definite interest to the concrete constructor. Two, on crazing and hair cracking, touch one of the most annoying of all the problems in the use of cement mortars and concretes. They leave the practical builder only a little farther advanced in working knowledge and by the same token indicate the intensive need of continued testing and experiment. Two other papers outline tests of direct usefulness to the constructor. It is a definite gain to have learned that field transverse testing can be done with smaller beams and therefore a gain in handiness of apparatus and procedure which greatly extends the boundaries of usefulness of this popular field determination of concrete condition. The fourth paper, on factory floor construction, develops the economy and practicability of a new process to eliminate dusting.

The concrete designer will find interest in the action of concrete under load and the anchorage value of hooks and spirals.

Concrete Flow Under Sustained Compressive Stress

By Raymond E. Davis
Professor of Civil Engineering, University of California

IN ORDER to learn more of the influence of various factors (cement ratio, gradation of aggregate, moisture conditions of storage, age at time of loading, magnitude of compressive stress) upon concrete flow, that plastic deformation which takes place subsequent to the application of load, the writer in the summer of 1925 inaugurated a series of tests on plain concrete cylinders held in compression.

The tests are divided into two series, the 1925 series and the 1926 series. The 1925 specimens were cylinders 6 in. in diameter by 24 in. long loaded at an age of seven months to a stress of 640 lb. per sq.in. The 1926 specimens were cylinders 4 in. in diameter by 14 in. long, subjected at various ages (two days to three months) to sustained compressive stresses from 200 to 1,200 lb. per sq.in. All deformations were measured with a strain gage. In each specimen the load has been maintained constant by means of a car spring reacting against one end of the cylinder, car spring and specimen being clamped by a system of rods and plates. The desired load is applied by compressing the car spring in a testing machine. A number of specimens were stored in air, others in water spray and still others under water, all at temperatures of 70 deg. F.

The following conclusions are based upon observations made to date. The tests are still in progress.

1. The leaner the mix the greater the flow.
2. The smaller the fineness modulus the greater the flow.
3. Variations in gradation of the aggregate, as measured by the fineness modulus, have a relatively greater effect upon the magnitude of the flow when the mix is lean than when it is rich.
4. The flow of a given concrete stored in air is materially greater than that of the same quality of concrete when stored in a water spray.
5. As between wet and dry concrete of the same character, the flow appears to vary inversely as some function of the modulus of elasticity determined by dividing stress by elastic deformation, but the concrete of the higher ultimate compressive strength does not necessarily exhibit the lesser flow, nor does the concrete of the higher compressive strength necessarily possess the higher modulus of elasticity.
6. The strength after the period of loading is lower for a given concrete stored in water spray than in air, but the modulus of elasticity is in general higher for concrete stored in water spray.
7. The higher the sustained stress the more rapid the rate of flow and the greater the flow after a given loading period.
8. When all specimens are cured in sand until loaded, those stored in air for a long period exhibit a materially greater flow than do those stored under water. The older the concrete at the time of loading the greater the relative difference between flow accompanying air storage and that accompanying water storage.
9. The older the concrete at the time of loading the less the flow.
10. Under the action of loads sustained for one year, the ratio of the flow to the elastic deformation at the time of applying the load is greater than unity for specimens in air storage, but in general is less than unity for specimens in water storage. Also, the lower the stress the larger the ratio of flow to elastic deformation.
11. The flow during the first seven days is greater than during the succeeding three months.
12. The secant modulus (unit stress divided by corresponding total deformation) increases materially with time.
13. The secant modulus changes more rapidly when concrete is under sustained stress in air than when it is in water.
14. The ratio of the secant modulus, at a given stress at time of loading, to the secant modulus after a period of sustained load appears not to vary greatly.

* * * *

Crazing and the Growth of Hair Cracks in Concrete

By Alfred H. White, Vilhelm A. Aagaard and Axel O. L. Christensen
Department of Chemical Engineering, University of Michigan

CRAZING is due mainly to the rapid evaporation of water from the surface of a rich cement mortar or concrete. The surface becomes dry in trying to contract, but is restrained by the main body of the material, which is still wet and swollen. The surface is thus placed in tension and hair cracks result. Portland cement, after hydration, is a mixture of crystalline and colloidal material, and the colloidal material expands when it is wet and contracts when it is dry. This property of behaving as a colloid is not lost with age. The colloid of cement requires many months in water for its full development, and the magnitude of the stresses caused by alternations of wet and dry conditions increases with the amount of colloid developed. The same forces that cause hair cracks are also adequate to make them larger and deeper, so that hair cracks may often become structural cracks.

The development of hair cracks is naturally greatest in rich mixtures, since the shrinkage is due to the colloidal properties of the hydrated cement. A hair crack in a lean mixture may be stopped when it meets a particle of aggregate. A surface that has been troweled is richer in cement and is therefore more likely to crack; it is also smoother, so that the crack is more easily visible. The failure to observe crazing in lean mixtures is frequently due to the irregular outline and lack of continuity of the cracks.

Crazing may be prevented by the use of lean mixtures and by keeping the moisture content of the concrete constant. It is immaterial whether the concrete is wet or dry so long as this moisture content is constant. Protective coatings and integral waterproofings of the water-repellent type are helpful. If integral waterproofings are used, care must be taken to keep the concrete damp until adequate strength is obtained, for after such waterproofed material has once become dry it will absorb water only slowly.

* * * *

Grinding Factory Floors Reduces Dusting

By Charles E. Covell
Eastern Construction Manager, The Austin Company, Philadelphia, Pa.

A GOOD concrete floor for ordinary industrial use must embody two essential characteristics: First, strength to resist compression and shear in the slab due to static loads of machinery and stored materials and to the concentrated wheel loads of moving trucks; and second, resistance to surface wear and dusting due to impact and the abrasion and crushing of the surface particles caused by truck wheels, the shoes of the workmen and loads dragged over the surface. The first of these requirements is easily attained by using a proper slab thickness, adequate reinforcement and care in producing a uniform concrete of predetermined strength. The second, however, is far more difficult to secure even when extreme care is exercised. This is especially true in industrial building, where the processes require the use of steel wheel trucks that tend not only to crush the surface but also to cut and gouge as the trucks are turned.

As the result of a series of studies of actual building operations and after various tests a choice of two methods seemed to be offered:

1. To secure a sand that is absolutely free of loam, organic impurities or the fine material. Our investigation of sands showed that it is possible to get good material at three or four different points in the Eastern district which would serve our entire territory in the East, but that the cost would be prohibitive, as there would be required the installation of special washing machinery and screens to take out the fine material and that the sand would have to go through a triple washing operation in order to be sure that all the fine material was removed. This increased cost of the sand would add from 3c. to 5c. a square foot to the cost of the finished floor, depending on the location of the work.

2. To use a sand that meets the specifications for complete sand for other types of work, if after the floor was finished we could remove the skin of poor material on the surface by grinding.

We decided to give this second method a trial and first used it on an industrial plant in Virginia. In this case we had a monolithic floor laid directly on grade. The floor was 5 in. thick and unreinforced except at machinery pits. The concrete mix was 1 : 2 : 3½ using local sand that contained a large percentage of material too fine for the purpose and a crushed limestone ranging in size from ¼ in. to 1½ in. This stone contained small particles of shale or clay material. No attempt was made to place any type of topping, the concrete merely being mixed quite dry, placed in position and struck off with a straight-edge, a tamper and a long-handled darby to a fairly level surface. The floor was cured under wet sawdust. The grinding was started when the floor had cured for five days.

The finishing process was carried on by the use of three hand-operated electrical grinding machines, and sand as an abrasive material was used under the cutting heads of carborundum to assist in producing a smooth surface. Plenty of water, however, was used during the grinding operation. No attempt was made to produce a true and even-textured surface, the desire being merely to remove all dirt, laitance and float marks left by the straight-edge and darby. This resulted in a floor that showed areas resembling a fairly good trowel job and other areas where the aggregate was exposed. There was a small amount of pitting, due, in all probability, to the clay content of the aggregate and possibly to accumulation of fine sand in pockets that were picked up under the grinding.

Accurate costs were kept on the work and it was found that this method of finishing was costing only slightly more than 1c. a square foot, including labor, machinery rental, supplies and power. The cost of the rough base was also quite low, because little if any overtime was required in producing a surface smooth enough for grinding. From this first job and several succeeding ones where the floors were laid in about the same manner and totaling about 1,000,000 sq.ft., we learned a number of important facts, viz.:

1. At least ten days must be allowed to water cure the floor before grinding it.

2. Coarse aggregate containing any considerable amount of flat elongated particles or of soft particles will cause pitting of the surface when the floor is ground.

3. The top surface of the concrete floor must be of a richer mix than that obtained by the use of 1 : 2 : 3½ or 1 : 2 : 4 concrete.

4. The use of a smaller maximum size of aggregate in the top will give the finished floor a more uniform appearance.

We then revised our specifications to incorporate these changes, and the floor of the building for the Wildman Manufacturing Company at Norristown, Pa., was laid with a base course 4 in. thick of 1 : 3 : 5 concrete, placed with 2-in. slump. This base was leveled off and immediately a 1 : 1 : 1 top coat, consisting of cement, concrete sand, and pea gravel was applied to a thickness of 1 in. This top coat was placed also with a 2-in. slump. This topping was leveled off with a straight-edge and finished with a wood float and a single application of steel trowel. The surface was then covered with wood shavings and kept wet for ten days. At the end of this curing period, grinding was started, it being done from ten days to three weeks after placing the concrete. This floor turned out to be, in appearance and apparent hardness, vastly superior to any floor we have ever laid, the surface being smooth, hard and close-grained, with apparently no dusting. Average costs for all of the floors finished in this manner to date, approximately 1,200,000 sq.ft., are less than 3½c. per square foot, which includes cement finishers' labor for straightening, floating and finishing and all expense of grinding, viz.: grinding machine rental, power, grinding disks, etc.

* * * *

Progress of Studies on Crazing of Cement Mortars

By P. H. Bates and C. H. Jumper
U. S. Bureau of Standards

A SERIES of test panels of cement mortars have been under observation at the Bureau of Standards as a part of a program of research on crazing. This paper is a progress report, giving test procedure and some of the data so far obtained.

The mortars were prepared so that the surface area of the sands should at least be covered with a layer of cement; thus the mortars were designed on the basis of the number of square inches of area on a gram of sand per gram of cement in the mix.

Four different sets of test panels were prepared, each following the other as desirable changes in the specimens were dictated from observing the ones which had already been made. Those of the first series were placed on panels of glass, of thin rubber sheeting and of well-hardened cement mortar to observe comparisons with relation to crazing (1) of absorptive and non-absorptive bases, (2) of maximum and minimum adhesive surfaces and (3) of maximum and minimum changes in area difference due to drying out of the stucco during hardening. In seven to nine months there was no marked difference in the various panels so far as crazing was concerned.

A second series of panels using the same mix was made and placed respectively on glass plates and an absorptive mortar base.

Panels of the same type were next made under different atmospheric conditions (on the roof, in the laboratory and in a damp closet). At the end of 30 days all of the panels were placed on the roof.

The fourth set of panels was then made under rather closely controlled conditions of temperature and humidity.

In the matter of crazing there seems to be some slight evidence favoring the mixes with the high sand area-cement ratio. The data also show that the more of the fine sand present the less there is of a readiness to craze. The fineness modulus seems to be more erratic as a means of decreasing crazing tendencies. The effects of the control of the temperature and humidity are quite evident on comparing some of the data.

It is confessed that so far, after a year and a half of work, nothing very tangible in solving the problem of crazing has been discovered, but on the other hand an estimate of the magnitude of the effect of some of the several variables, particularly humidity and temperature, is being obtained. For the immediate future the work will be conducted along the line adopted in the latter series of panels. These data when obtained should indicate which of the stuccoes are better than others under the most severe conditions (such as high temperature and low humidity) and under the most favorable conditions (lower temperatures and higher humidities). In further studies different gradations of sand and different cements will be used in mortars.

* * * *

Carrying Capacity of Hook Anchors

By T. D. Mylrea
Professor of Building Construction, Carnegie Institute of Technology, Pittsburgh, Pa.

THE tests were made upon semicircular hook anchorages of various sizes, reinforced with spiraling of varying amount. They comprised (1) three-, six-, eight- and twelve-diameter hooks without spirals, (2) five-turn spiral on flat bend and three-, six- and eight-diameter hooks, (3) seven-turn spiral on flat bend and on three-, six- and eight-diameter hooks, (4) ten-turn spiral on flat bend and three-, six- and eight-diameter hooks, (5) three-, six-, eight- and twelve-diameter hooks without spiral—a check test on series 1, and (6) ten- and twelve-diameter hooks without spirals cast in lumnite cement concrete. Great refinement was sought in testing apparatus, measuring devices and the segregation of all influences on results except the one desired. The general conclusions were:

1. It is evident flat bends, spiraled or unspiraled, do not form a satisfactory anchorage; no flat bend developed the elastic limit of the steel.

2. Hooks 3*d* in diameter do not behave much better, although there is still the possibility that if the straight piece at the end were extended for, say, three to six diameters farther and inclosed in a long spiral in the nature of a long sleeve, the breaking out of the whole spiral might be prevented. Only one 3*d* hook, with five turns of spiral, in 2,500-lb. concrete, developed the elastic limit of the steel.

3. All 6*d* and 8*d* spiraled hooks developed the elastic limit of the steel and one 8*d* spiraled hook in 2,200-lb. concrete developed the ultimate strength of the steel.

4. The 10*d* and 12*d* hooks, unspiraled in 3,200-lb. concrete, developed the elastic limit of the steel with a slip of 0.05 in.

5. Hence increasing the diameter of the hook increases the load-carrying capacity, and spiraled hooks showed greatest strength, but it is hard to see any direct relationship.

6. The strength of the concrete has some influence.

7. The size of the specimen to be split certainly has something to do with the strength of the unspiraled anchor; regardless of hook diameter, all unspiraled specimens were split, even though the depth of the block was eighteen times the bar diameter.

8. The size of the specimen had little to do with the strength of the spiraled specimens, for hooks of 6*d* or greater either crushed the concrete or pulled around the band.

9. Slip was evident at the point of tangency from very low loads, and movement of the whole bar was evident at loads far below the ultimate strength developed. Since the prevention of slip is an important function of an anchor, hooks have still to demonstrate their right to be styled "adequate" anchors. The fact must not be overlooked that the values obtained in this investigation were comparative only and that no time was given for the very evident tendency for "time-slip."

* * * *

Small Beams Give Valid Results in Field Tests

By C. A. Wiepking
Testing Engineer, Department of Public Works, Milwaukee, Wis.

WITH the object of reducing the task of making transverse tests of concrete in the field, a study was made in 1927 by the Department of Public Works of Milwaukee, Wis., to determine whether a beam 4x6x24 in. would give results as valid and useful as the more common 6x8x30-in. beam-test specimen. The smaller beam, if it gave reliable indications, reduced the weight of specimen to be handled about 75 lb. and correspondingly cut down the weight and bulk of the testing apparatus and the magnitude of the test weights to be shifted for each test. Beams of both sizes of various aggregates and various mixes were made and for each mix compression cylinders were molded for supplementary tests. The general conclusions from the tests are:

1. The 4x6x24-in. beam can be used effectively for testing concrete of workable consistency having a maximum size of aggregate of 1½ in. A small amount of material up to 2 in. might not interfere with the manufacture of good specimens if the mix is workable. For larger-sized aggregates a corresponding larger beam should be used, but always with greater depth than width so that the concrete will have enough bulk to puddle easily.

2. Since practically all concrete construction requires a workable mix, no difficulty will ordinarily be encountered in molding the small-sized beams. Reinforced-concrete columns, beams, floor slabs and piles call for aggregates of a size range than can be puddled properly in 4x6-in. specimens.

3. Some 6x12-in. cylinders for compression tests should be made for comparison with beam tests. As soon as the requirements for the beam test have been established, it will be necessary to send cylinders to the testing laboratory only occasionally for check purposes. If a minimum test load is desired for ease in handling, the 4x6-in. beam may be tested flatwise—that is, with 6-in. faces horizontal.

Concrete With 2-In. Slump Delivered in Chutes

Specifications for the North Spring St. bridge, recently completed at Los Angeles, required the use of concrete with a slump not exceeding 2 in. for footings, shafts of piers and abutments. The contractor successfully chuted to place both Class A and Class D concrete (specified as 1:2:3½ and 1:3:6 mixes, respectively) that were within these slump requirements. In fact, some of the Class D concrete so placed showed a slump as low as ½ in. The chute slope was 5½ in. vertical per foot horizontal. The materials were specially proportioned by the void method so that the quantities, instead of being in the proportion allowed by specification, were actually 1:2.7:6.3 for Class D, and 1:1.58:3.92 for Class A. No admixtures were used. The rock was graded in two sizes, from ¼ to 1 in. and from 1 to 1½ in., respectively, these sizes being combined so as to correspond with a grading curve showing maximum density. Materials were measured by the batcher and sand inundator method, mixed in a 1-yd. mixer, hoisted in a skip and delivered by chute a maximum horizontal distance of 320 ft. without any unusual difficulty in the delivery system. H. P. Cortelyou is engineer of construction of the Los Angeles engineering department.

Pneumatic Caissons Sealed at Record Depths, Using Quick-Hardening Cement

Quick-Hardening Cement Decided Factor in Rapid Founding Under Air of Kennebec River Bridge Piers—Caissons Sealed at Maximum Water Depths of 125 Ft. on Rough Rock Bottom

By C. K. Allen
Resident Engineer, Kennebec Bridge, Bath, Me.

IN CONSTRUCTING the substructure of the Kennebec River bridge at Bath, Me., it was necessary to sink the river piers to great depth in a strong-flowing tideway, where the depth of water at mean tide was about 40 ft. for the greater part of the width. The piers, seven in number, were sunk by the pneumatic process, and three of them are founded at greater depth than any ever before sunk by this method. The rapidity of the construction under very difficult conditions sets a precedent of interest to all civil engineers and foundation contractors.

The bridge crosses the Kennebec River from Bath, Me., to Woolwich, Me., and is a double-deck steel structure, the lower deck being used by the Maine Central Railroad and the upper deck as a part of the state highway system. There is a vertical lift span in midstream to provide a passage for vessels.

A general plan and elevation is given in Fig. 1. Fig. 2 is a record of the conditions of founding and sealing the caissons. In reading this drawing, one should keep in mind that the arrows of greatest depth refer to the depth below mean tide level and that a high tide is from 5 to 6 ft. more, so that at Pier 3, where the depth is shown as —109.94 at high tide, this becomes 109.94 plus, say, 5 ft., or 114.94 ft. below the surface of the water; and taking Pier 2, the same process gives a depth of 124.7 ft. below surface at high tide.

Caisson Sinking—The piers are all founded on a very hard and irregular granite ledge, so irregular that in some cases there was more than 13 ft. difference in extreme elevations of the rock surface under a pier. This granite was found to be very hard to drill and did not break up well when blasting, requiring heavy charges. To blast out all ledge and bring the cutting edge of the caissons on to ledge all the way around would have been a very slow and expensive operation and but little if any additional stability of the piers would have been obtained than was obtained by resting on the higher portions and then underpinning the entire area.

At all of the piers there is a deep bed of coarse, very heavy sand immediately under the water superimposed on a deep bed of plastic blue clay. This clay extends down to the ledge in Piers 3, 4, 5 and 6; at Piers 1 and 7 the clay is not present, as they are shallow piers. At Pier 2, the deepest, the caisson passed through the clay on to what appeared to be a pot hole in the top of the ledge. This depression in the ledge was filled with sand and boulders. Pier 2 was by far the hardest one to found, for whereas in the other piers the clay enabled us to depend on it to seal out water so that we could carry a lower air pressure than is required in pervious materials, in this pier we had to work under a pressure in excess of 50 lb. per sq.in. for several days.

In founding by underpinning between the cutting edge and the rock, it becomes necessary to block the caissons to prevent tilting. At the Kennebec bridge we did this by excavating over a small area under the cutting edge and cleaning off the surface of the ledge and, if necessary leveling it off; then sacks of concrete mixed of quick-hardening cement were laid up as a pier to give bearing under the cutting edge. Other piers, as required, were built the same way. Then the rock was excavated where in contact with the steel cutting edge until sufficient hold was obtained on the ledge to eliminate any tendency of the pier to slip. The entire area under the base was then cleaned out of all material to the ledge, and the surface washed with a stream of water under pressure and scrubbed with brooms until clean. Several cubic yards of grout were then placed on the bottom by buckets lowered through material shafts, after which the concrete was dropped from the top. Workmen and an inspector remained in the caissons during the sealing until the concrete was well above the cutting edge.

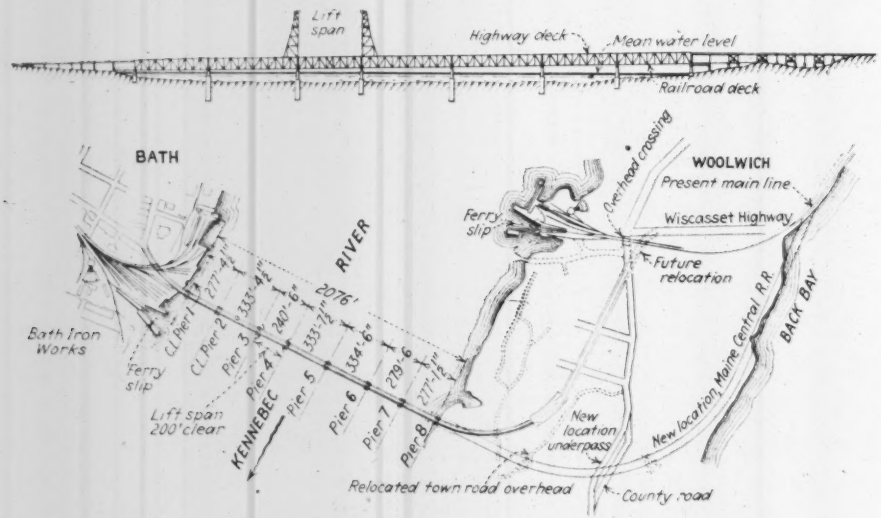


FIG. 1—PLAN AND ELEVATION OF KENNEBEC RIVER BRIDGE

In most of the piers the clay, while plastic, would stand for hours when cut vertical under the cutting edge for 5 ft. or even more. This made the matter of excavating below cutting edge rather an easy matter, but in Piers 1 and 2 conditions were different and called for great care and special methods of holding the sand and

boulders from rolling in. This was accomplished by use of sacks of concrete in shallower parts and by plastering vertical surface with portland cement as fast as excavated, but both wood and steel piles were used to shut off the material where the excavation was deep. In some cases the sheet piles were driven in two tiers as by the old method of shaft sinking by miners. Then grout was blown in between the two tiers and under the cutting edge, and next to the upper tier. This sealed the two tiers of piles and the piles to the cutting edge, so that with care in keeping them well braced, rock was reached successfully at a depth in one case of more than 12 ft. below the cutting edge through sand and boulders. This is thought to be a departure from old methods.

Concrete Under Pressure—One sometimes hears engineers state very positively that concrete dropped from a great height always splashes and separates. They should spend an hour or so in a caisson like those of the Kennebec bridge while the concrete is being slushed in, and they would be surprised at the action of the large mass. Of course, the mixture was rich in cement to begin with and it was all soft enough to run readily in a trough from the mixer tower to the air lock hopper. One yard or more was placed in the lock at a time, then shot in one slug, so to speak, to the bottom. The impact of this falling concrete carried it into the other concrete like a projectile, and there was but little splatter after, say, 3 ft. of concrete had been placed, and this was always placed with a bucket where the concrete was to

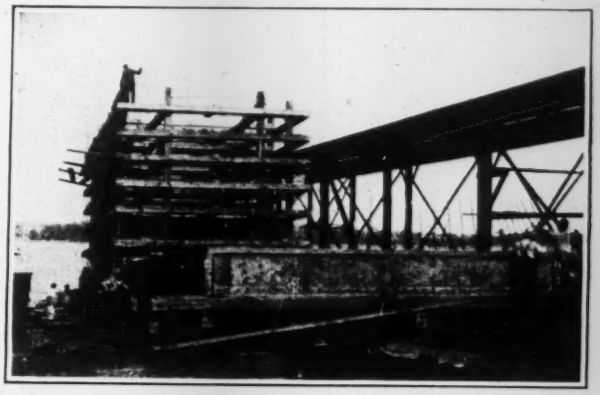
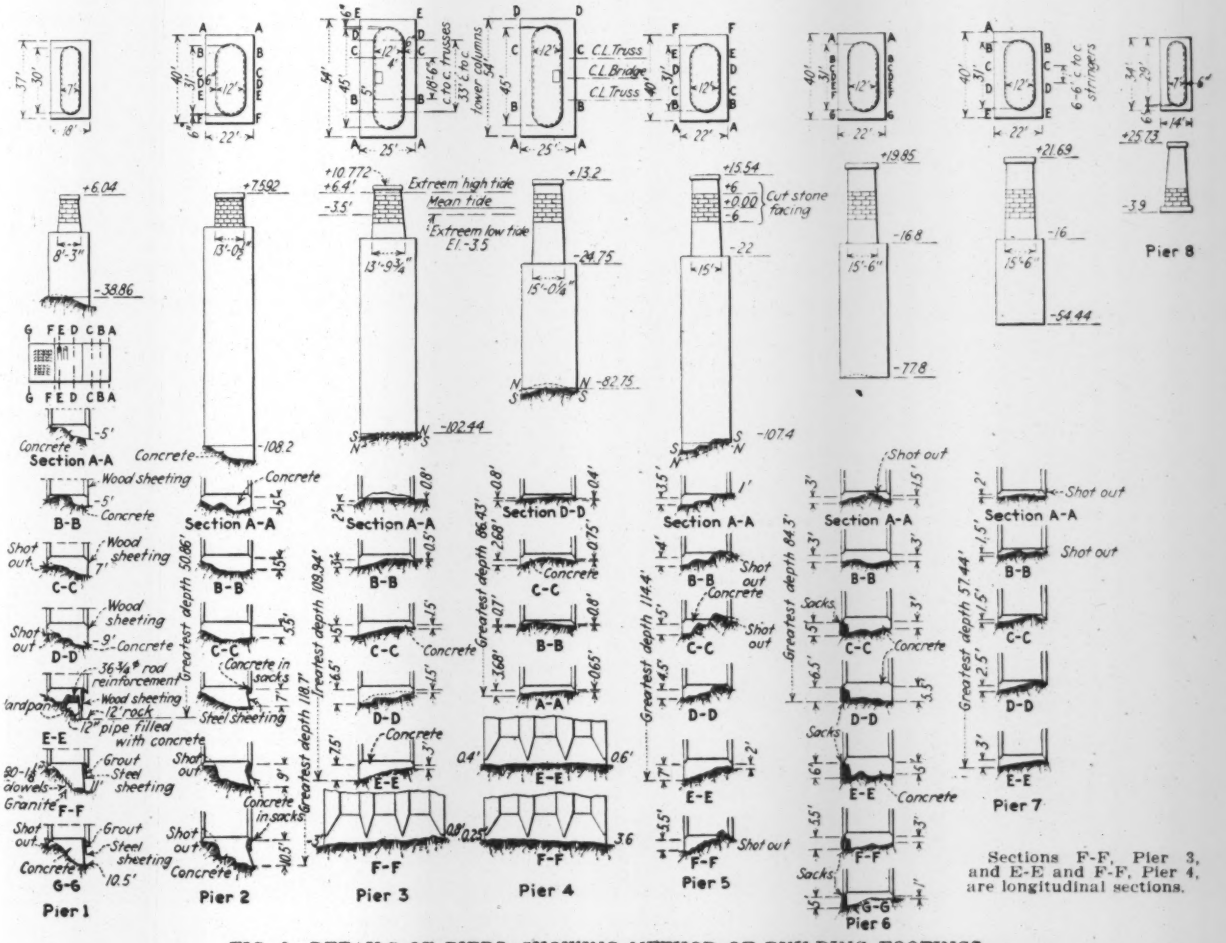


FIG. 3—TWO CAISSONS UNDER CONSTRUCTION ON THE LAUNCHING WAYS

fall before dropping the concrete from the locks. Full air pressure was maintained until the caisson was sealed and the concrete had set. Now, had concrete been placed in an area of equal size under normal atmospheric pressure, mixed as this was, a man stepping on it would have sunk over his boot tops, but in the caisson, under high air pressure, a man could walk on the surface at any time and merely make a track in the mortar after the concrete had reached the cutting edge. The air pressure forces excess grout into the materials outside of the cutting edge until they are filled with grout.



Sections F-F, Pier 3, and E-E and F-F, Pier 4, are longitudinal sections.

FIG. 2—DETAILS OF PIERS, SHOWING METHOD OF BUILDING FOOTINGS

FIG. 4—FLOATING CONCRETE MIXING PLANT
The barge was equipped with a derrick for transferring material from lighters to the sand and gravel hoppers and cement shed.

The entire substructure was completed within about twelve months from the start, and there was a period of about four months when the ice prevented work in the river, leaving only about eight months' time in which to place and complete the seven piers in the open water. This result was made possible by the large and complete plant and the use of quick-hardening cement for part of the work.

Material Supply—Compressed air was supplied from a plant built on the shore just above the bridge and shown in Fig. 7. There a battery of four compressors operated by electricity furnished all air required for sinking of all piers. Two submerged pipe lines with flexible joints conveyed the air to the various caissons. These pipes rested on the bed of the river with a riser at each pier to which 4-in. flexible rubber hose was connected. Sand required for the concrete was delivered in cars near the air plant, and a stiff-legged derrick at the wharf edge loaded the sand on big lighters as required. All other operations on shore had to be at the plant of the old Bath Iron Works, a large shipyard, which was the only place available. Here the caissons were built on and launched from the old shipways. Fig. 3 shows two caissons on the ways in course of construction.

A large gantry crane unloaded lumber and other material from railroad cars and delivered them on the dock for storage; the gravel required came in railroad cars and was run onto an elevated trestle near the face of wharf, from which it was dumped to the wharf. A derrick loaded it on lighters as required. A railroad spur track delivered cars of cement to a warehouse, where it was stored in large quantity, and from there an industrial track delivered it to lighters. Fig. 4 shows the concrete mixer barge anchored at the wharf near this gravel pile. The mixer barge was equipped with a 1-yd. mixer with a couple of hoppers above it for sand and gravel and a weatherproof house that held about a carload of cement. A derrick near the center of the barge transferred materials from lighters to hoppers and cement house as required, and a steel tower elevated the concrete to a height sufficient for spouting to place. This barge could and did deliver 40 cu.yd. per hour continuously. Fig. 5 shows the concrete barge working at Pier 3, while a derrick boat is laying the two lines of submerged air pipe.

Considering the large amount of work under high air pressure, it is remarkable that there were no deaths from

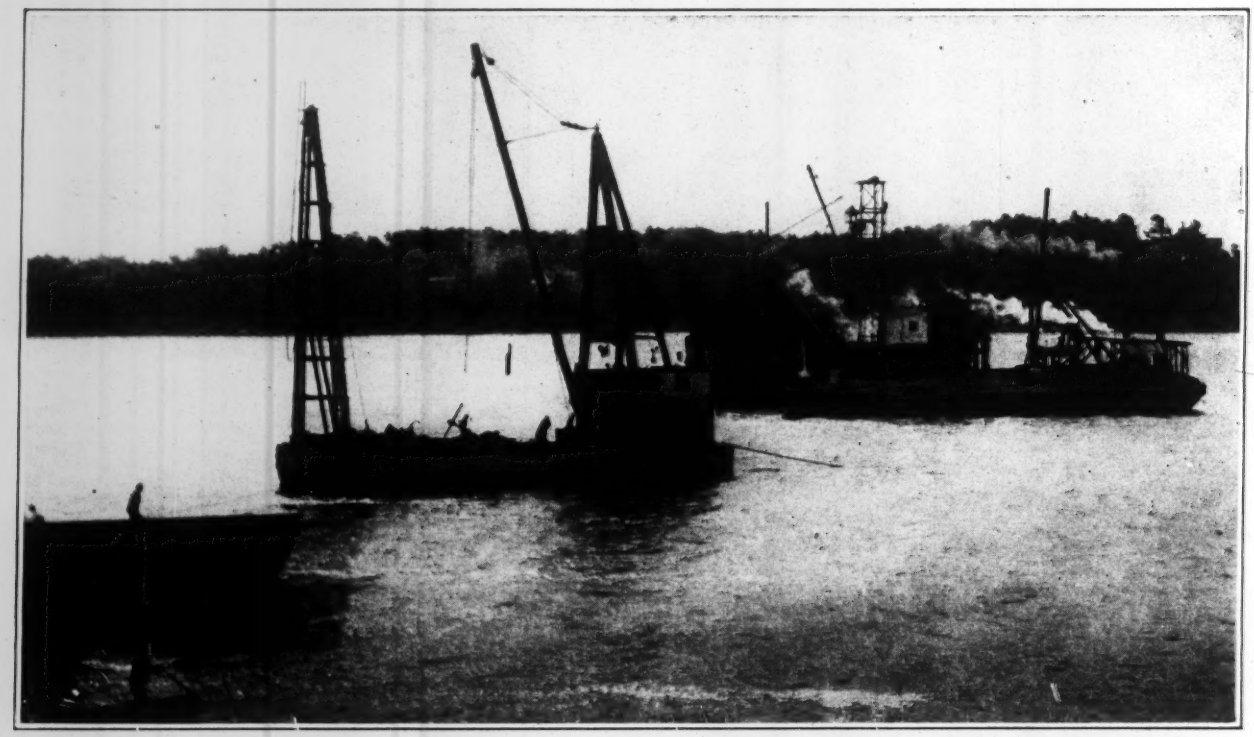


FIG. 5—EARLY STAGES OF THE WORK
Concrete barge at Pier 3, piledriver driving dolphins for caisson at Pier 2 and derrick boat laying submerged air supply line at extreme left.

air, though there were many cases of the bends, some of them quite severe. All the men were carefully examined by a physician before being allowed to go under air. A well-warmed house was furnished for their convenience, with a hospital lock for those with bends. In Pier 1 a man who had been gassed in the war returned to where they had blasted too soon after the shot and inhaled powder fumes from which he died, and one man was killed while unloading 80-ft. piles from a ship. These were the only serious accidents.

Caissons—In Fig. 6 is shown a vertical cross-section through one of the caissons to illustrate the way the caissons were constructed to enable the sinking for the greater part of the depth to be done by open dredging. This method was used until the caissons had penetrated well into the clay; then forms were placed across the dredge wells and the lower 3 ft. of a deck placed. This deck was composed of a slab of concrete made with quick-hardening cement, well reinforced, and dovetailed into the sides of the dredge well. This slab was allowed to set and harden 24 hours; then similar concrete was placed and the steel man- and material-shafts were put

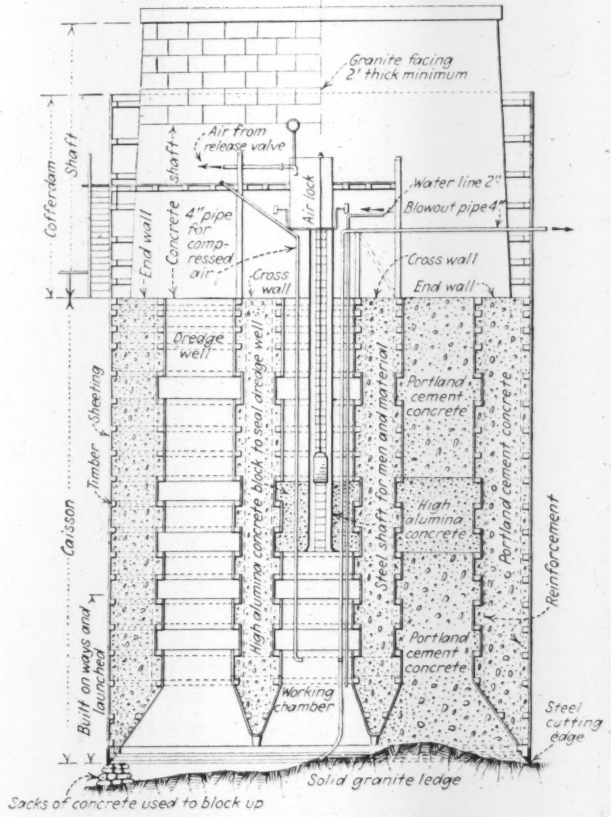


FIG. 6—VERTICAL CROSS-SECTION OF A CAISSON SHOWING SEVERAL STAGES OF PROGRESS

on, with the air locks always at the top. Air pressure was turned on in less than three days from the time the first of the deck concrete was poured. This hastened the construction of each pier at least two weeks, because, had ordinary concrete been used, it would have required the additional time before becoming strong enough to retain the air pressure. All the river piers are built with concrete decks over the air chamber, and all the wood required as forms under deck was removed, so that in these piers there is continuous concrete from the ledge

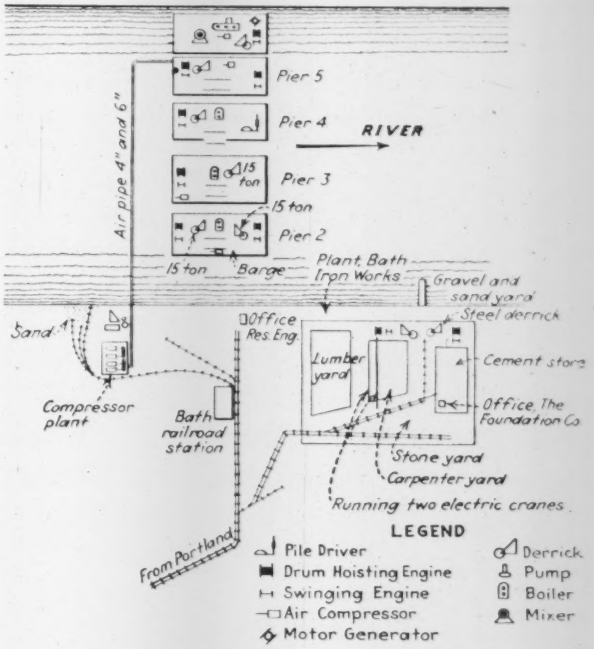


FIG. 7—LAYOUT OF THE CONSTRUCTION PLANT

to the top, with no timber remaining in the structure to compress or be destroyed by the Teredo navalis or other borers. The outer walls and transverse walls of the caissons were reinforced from the steel cutting edge to the top of crib, the vertical bars being fastened to the steel cutting edge. Caissons were built to a height of a little over 20 ft. on the ways, and launched; then they were taken out and moored in position, being held in place by six Chinese anchors, two of which weighed about 35 tons each, and four about 5 tons each. The setting and holding of these caissons in proper position until well sunk into the bed of the river was quite a job in itself, because of the shifting strong currents.

The designing and consulting engineer was J. A. L. Waddell, of New York, assisted by Shortridge Hardesty. The writer made preliminary surveys and investigations and has had entire charge in the field. The Foundation Company was the contractor, R. B. Alsop superintendent under the direction of T. S. Crowell, assistant district manager. The entire job has been remarkable for the speed and good teamwork of the organizations. The cost of substructure was $1,070,961.

Weathering of Brick Walls

Speaking on the weathering of brick before the recent convention of the Common Brick Manufacturers Association, J. W. McBurney, Bureau of Standards, said that no evidence has been presented showing a relationship between water absorption and weathering. The only absolute test for weather resistance is 100 years' or more exposure. Repeated freezings and thawings conducted in the laboratory are the next best test. Brick of a relatively high absorption and of a high rate of absorption is desirable from several standpoints. The bond between brick and mortar is better with absorbent brick. On the basis of a limited field inspection, the chance of a dry wall is better with a porous absorbent brick than with vitrified brick.

Abolition of Cross-Connections Causes Lively Discussion

Compromise N.E.W.W.A. Report Gets Little Support at Meeting and Will Go to Members for Study Before Vote

EPIDEMICS OF TYPHOID FEVER and other intestinal disturbances traced to the pollution of municipal water supplies through cross-connections to non-potable sources of supply used for industrial purposes or fire protection have caused action designed to outlaw such connections. Resolutions against them were adopted by the Conference of State Sanitary Engineers in 1921, by the fire protection division of the American Water Works Association in 1925 and by the entire association in 1926. At least ten state health authorities have prohibited them, six have forbidden new cross-connections and eight permit them only where double check valves are used. Following the action of the two other associations named, the New England Water Works Association appointed a committee on the abolition of cross-connections in 1926. An abstract of the committee's report, as presented March 14, and the ensuing discussion, follows.
—EDITOR.

ABOLITION of cross-connections was the sole topic for discussion at the luncheon meeting of the New England Water Works Association held in Boston on March 14. The subject came up in the form of a report of a committee authorized at the convention of the association in September, 1926, consisting of four state sanitary engineers, two consulting engineers, two water-works superintendents and two representatives of Factory Mutual Fire Insurance Companies. The report was about 45 pages in length, including some 25 pages of appendices, one of which is here called subcommittee report No. 2. The report proper contains a short subcommittee report, called below No. 1, for which no responsibility is assumed except by the subcommittee which drew it.

Fire Hazards—In its introduction to the report of subcommittee No. 1, charged with presenting "the practical importance of cross-connection for industrial use and fire protection," the whole committee stated that the "principal demand for cross-connections comes from fire insurance companies and from property owners who desire two rather than one source of water supply for additional protection to life and property. Opposition to cross-connections has come principally from the health and water-works authorities, largely because numerous epidemics have been due to these connections."

Many industrial and utility plants require "some secondary stand-by supply" of water, "instantly available in emergency"— especially for sprinkler systems for this purpose. "Municipal water supplies *alone* cannot be depended upon in all cases" because they may be out of service and "are frequently *inadequate* in volume and pressure for the large number of automatic sprinklers and hose streams which might be needed to cope with a serious fire." In 296 instances, on record with the Associated Factory Mutual Fire Insurance Companies, where the "public water supplies have failed or been interrupted" there were twelve cases in which "fire broke out simultaneously with the interruption of the water supply." New York State labor laws permit "double the number of employees in a building equipped with a sprinkler system supplied from two independent sources."

Secondary supplies of sufficiently large capacity to be serviceable in case of an "unusually severe fire or a conflagration" are usually impracticable in cost but "can be obtained by utilizing . . . ponds and rivers," in which cases "a cross-connection is the only practicable method at present available of combining the existing potable public water systems and the available non-potable secondary supplies of large capacity, both automatically feeding into a common fire protective system capable of meeting the demands of sprinklers and hydrants during the progress of the fire. Such a cross-connection, in order to function instantly when fire occurs, cannot be dependent upon manual operation, but must be automatic."

Health Hazards—Subcommittee report No. 2, in the form of an appendix giving a partial list of epidemics due to cross-connections, is abstracted in the main report as follows:

In 22 of these instances a cross-connection contained a single gate or check valve. It must be borne in mind that a gate valve is not an automatic device and that it affords no protection unless closed. In two instances protection against mixing of unsafe with safe water was afforded by two gate valves or by a check valve and a gate in series, and in one instance there were two gate valves and a check valve in series on the cross-connection. In one instance it might be assumed from the wording of the published record that protection against pollution was afforded by two gate valves and a double check valve arranged in series, although this was not definitely stated. In another case this condition was definitely stated. It is also true that one of the double check valves which failed was of inferior type and one had not been inspected recently.

In reviewing the position of public health authorities the report says:

While from the broad economic viewpoint it may be undesirable to run the risk of fire losses and, possibly, some losses of life by accident to firemen and industrial employees, [yet], to avoid the other hazard of sickness and death due to the effect of cross-connections, the saving of life rather than of money must always be the dominant motive for sanitary authorities.

Legal Liability—On the subject of legal liability the report states:

The legal cases which are cited in the report of the State Sanitary Engineers (given in an appendix) support the position that municipalities which through their officers permit cross-connections with polluted supplies become legally responsible for any epidemics resulting therefrom. In the opinion of the committee they become legally liable if the epidemics result from any negligence in the design, installation, operation or inspection of said connections. It is also true that equal if no greater responsibility rests upon state authorities regarding cross-connections, even though moral rather than legal.

Relative Hazards—The report refers on the one hand to the figures already given as to twelve cases of fires occurring when public water supplies were interrupted

and on the other hand to data collected by the State Sanitary Engineers (given in an appendix) showing 8,028 cases of typhoid, with 226 deaths, and more than 11,000 cases of enteric disturbance with losses by death and disability running into millions of dollars. Most of the "deaths followed pollution through single valves or checks" [not double check valves—Editor]. The report states: "Apparently any single valve is too hazardous a connection between a potable and a polluted source of supply, and even the best installation of double check valves may fail for lack of inspection."

Of 1,032 sets of double check valves inspected by the Mutual Companies there were only "four cases where both valves were leaky, and in these four leakage was slight and due to lack of care." Mention is made in the report of a case where both clappers of a double check valve were held partly open by a pair of overalls (see *Journal* N.E.W.W.A., Vol. 36, p. 406). [As bearing upon this overalls incident, it was stated in the course of the discussion that the improved form of double check valves now made have the two valve support parts so that overalls stoppage would be caused only by the garment of a giant.]

Inspection of double check valves on cross-connections at New Bedford, Mass., many of the installations not being of related types, showed both valves leaky in only two out of 2,152 tests. Inspections here are made twice a year.

In Connecticut, where periodical tests are made by the State Department of Health, in 273 tests of "all bronze valves" [presumably the latest improved type], leaky valves (outside only) were found in three cases, and in no cases were both valves leaking. In contrast, "out of 624 tests on iron body check valves, there were 24 cases where one leaky valve was found and one case where both valves were found to be leaky because of unevenness in the flat, rubber seat facings."

Factory Mutual Resolutions—The report expresses appreciation of resolutions adopted Dec. 12, 1927, by the Associated Factory Mutual Companies. Besides making careful inspections and overhauling of double check valves and with apparent reference to the mooted question as to the abolition of all cross-cennections, these resolutions stated:

(*b*) Pending the decision in each case as to the final outcome, see at once that every single check valve between potable and non-potable supplies is made accessible and kept tight, as is being done in the State of Massachusetts. (*c*) Make a study of fire service connections at our plants, both insured or prospective, and determine where it would be wiser to eliminate cross-connections and where best to provide other supplies. Then for those risks where cross-connections should be retained, have all-bronze double check valves put in and provide for periodic and effective supervision of them.

Conclusions—The final conclusions of the committee, agreed to by all of its members, follows:

The committee recognizes that the only absolute safeguard for the purity of water supplies is complete separation between potable and non-potable supplies. Many cases exist in industrial as well as fire lines where cross-connections can be entirely eliminated without extensive changes or undue hazard to life and property. Such connections should be immediately abolished. In other instances the abolishment of such cross-connections presents a very serious problem from the standpoint of possible loss of life and property from fire. Each case should be carefully studied on its own merits to determine the best procedure, all interests being considered. So far as possible steps should be taken in each community to provide public water supplies of sufficient adequacy and reliability, even to providing a secondary potable supply if necessary, so as to eliminate the necessity for cross-connections of any kind.

The committee feels that pending the establishment of adequate and reliable supplies for protection of life and property from fire, experience to date indicates that double check valves of the latest improved type, properly installed and adequately supervised, furnish the best protection of any device now known. It is essential, however, that such installations be regularly and frequently inspected and tested. Installations of this type are relatively recent, and whether or not such installations, properly supervised, give sufficient protection is a question which is still open for decision on the basis of further experience.

Your committee does not advise the use of double check valves as protection against supplies which are subject to gross pollution by sewage or industrial wastes, nor against supplies which are subject to more or less frequent direct pollution by human wastes from near-by sources. Theoretically, the best double check valves may fail, and although present experience indicates that the danger of such failure is relatively small, this danger to health must be carefully balanced against the fire hazard to life and property.

The elimination of cross-connections is bound up with the approval of the quality of auxiliary supplies and local influences which may introduce complications, so that it seems to your committee that regulations relative to cross-connections should be adopted by properly authorized state bodies. This does not mean, however, that a larger degree of responsibility should not rest upon the management of a water supply maintaining cross-connections.

While this report is largely concerned with cross-connections for fire service, there are many other cross-connections like those with sewers, around water purification plants and through auxiliary intakes. None of these should be permitted.

Resolutions—The following resolutions were submitted by the full committee for adoption by the association:

Whereas, evidence shows that the existence of certain cross-connections between potable and non-potable water supplies has resulted in many outbreaks of disease and many deaths, and *Whereas*, such cross-connections are admittedly a hazardous part of any water supply system, *Whereas*, it is necessary not only to protect water supplies from pollution but also to safeguard property and life against fire, *Therefore, be it resolved* that the New England Water Works Association places itself on record as follows:

1. The association urges the development of all public potable water supplies to a state of sufficient adequacy and reliability, even to providing a secondary potable supply if necessary, so as to eliminate all such cross-connections.

2. The association recommends that all such cross-connections, including emergency intakes and bypasses, which can be abolished without undue fire hazard to life and property be immediately eliminated.

3. Pending such elimination double check valves of the latest improved type, properly installed and adequately supervised, are considered to be the best safeguard now known for minimizing the hazard of pollution through cross-connections where local conditions indicate the need for such connections.

4. Even with the best double check valve installations some possibility of pollution remains, and for this reason no cross-connections whatever should be allowed where secondary supplies are of a raw water quality which would be bacteriologically unsafe even with purification or where proper installation and supervision are not maintained.

5. The association strongly urges that states adopt suitable laws and regulations covering the control of cross-connections and that in each community an investigation of the existing cross-connections be made immediately and a program for the control thereof be inaugurated by the local authorities.

6. The association recommends that where possible the inspections be made through the co-operative efforts of state and municipal authorities on the one hand and owners and insurance companies on the other. Inspections should be made at least quarterly by an official responsible for the quality of the public water supply; devices should be overhauled yearly.

Discussion—As chairman of the committee, Robert Spurr Weston moved the adoption of the resolutions. The ensuing discussion was opened by X. H. Goodnough, chief engineer, Massachusetts Department of Health, who was requested to speak on cross-connections in Massachusetts. Mr. Goodnough stated that he believed there are no cross-connections in Boston, but outside the city there are many. The Massachusetts State Department of Health has no legal control over cross-connections, and it is doubtful, Mr. Goodnough stated, whether such authority could be obtained from the state Legislature. This control, he thought, had better be left to the local authorities.

Stephen DeM. Gage said that as a state health officer he did not like cross-connections, but since working on this committee he has had a growing realization of the relative dangers to life and property from fire on the one hand and on the other to health. Patrick Gear, superintendent of water-works, Holyoke, Mass., expressed sympathy with factory and mill owners in the present hard times confronting New England, even if called upon to do no more than install double check valves on cross-connections. He said he was in favor of the report but didn't want to go back home and face the possible consequences of its adoption.

Frank Barbour, consulting engineer, Boston, stated that if the entire 45 pages of the report were in line with the digest of it that had been presented, he did not see how anyone could vote for the resolutions. He thought it was pretty raw to balance health against fire risks. Caleb M. Saville, engineer and manager, Hartford water-works, also opposed the adoption of the resolution. He thought that the water-works men rather than the fire insurance or material men should have the say in such questions as this and that the association should go on record in favor of the interests of water-works men and leave the matter to states and localities for adjustment according to local conditions. He congratulated the committee on making a unanimous report in view of the divergent interests of its members, but added that oil and water will not mix and that engineers charged with the protection of public health should not compromise with engineers interested in fire insurance.

A leading representative of the factory mutual companies urged that the fire engineers have the public interest at heart as much as the health engineers and that the factory mutual companies are not working for profit but merely to cut down the fire risks.

M. N. Baker, New York City, expressed disappointment because the committee had not taken as strong a stand against cross-connections as has been taken by the Conference of State Sanitary Engineers and the American Water Works Association. He thought the report was too much in the nature of a compromise and felt that the hour or two available since the distribution of the proposed resolutions at the meeting did not give sufficient opportunity to make sure of their significance. He favored postponement of action until the membership had a chance to examine the whole report in connection with the resolution.

The motion to adopt the resolution was then withdrawn by R. S. Weston, chairman of the committee, and it was voted to have the full report of the committee printed in the June issue of the *Journal* of the New England Water Works Association.

Levee Railroad Track Jacked Up to New Grade as Levee Is Raised

IN RAISING most of the 12½ miles of levee at the lower end of the levee system that protects the Imperial Valley from Colorado River floods, it was possible to excavate material for the raise with the dragline immediately adjacent to the section on which the work was being done. On the last mile and one-half, however, at the lower end, the land adjoining the levee was so wet that it could not be handled in this way. A spur track

PREPARING TO JACK UP THE TRACK AS THE LEVEE IS RAISED

was therefore built some distance away, where dry material could be secured from borrowpits in the usual manner. Thus, on the lower end of the levee, material was delivered in dump cars that had been loaded at borrowpits on the spur. These cars were dumped on either side of the track but on top of the levee. Usually sufficient material was dumped to permit of a raise of 18 in. in the track grade, after which the track was jacked up this amount and then additional material was dumped for the next 18-in. raise. This program was repeated until the levee had been elevated to the desired grade, representing a total rise of about 4 ft.

After sufficient material had been dumped for the initial rise, small holes were dug under each rail joint and a track jack was set under each rail. The track was thus jacked as much as possible without danger of breaking the joints. This meant that the operation of raising was progressive, a slope always being maintained toward the portion that had not been raised. After the 18-in. rise enough material was tamped under the ends of the ties to support the train while material for the next lift was being dumped alongside, after which the same operation of jacking was repeated. When the final grade had been reached, careful alignment was made and the subgrade was compacted for the entire width of the ties.

This work has been done by the Imperial Irrigation District, M. J. Dowd, chief engineer.

News of the Week

Current Events in the Civil Engineering and Contracting Fields

Sanitation Congress of Lake States Discusses Industrial Wastes

Once every year there gathers in some municipality at the southern end of Lake Michigan a group of state and city officials, consulting engineers and others interested in the problem of taking sewage out of the lake and keeping it out. This year the congress met March 6-8 at Gary, Ind.

There has recently been an active movement on the part of Chicago to have abated the nuisance of phenol wastes driven by winds north from Indiana industries into the Chicago water-works cribs. Lewis S. Finch, Indiana state sanitary engineer, told how in November 42 city officials were called to Indianapolis and requested to proceed along lines that would result in something being done. Again on Feb. 8 the health authorities, the mayors and heads of industries in the Calumet region had a conference in which the industries expressed a willingness to cooperate and largely eliminate phenols and raw domestic sewage within a year. One industry will have to lay more than 10 miles of sewers and spend more than $100,000. Michigan City has already proceeded toward eliminating raw sewage discharge. Phenol elimination is the first consideration and only awaits certain refinements in processes now somewhat experimental. Evaporation has been successful, and so have biological methods in sewage disposal plants.

E. S. Tisdale, West Virginia state sanitary engineer, outlined the results of co-operative research by the phenol producing industries along the Monongahela River and the state boards of Pennsylvania, Ohio and West Virginia. At the Fairmount domestic coke plant recovery of phenols by benzol have been raised from 72 per cent to 97 per cent and the tastes in Morgantown water, 25 miles below, have disappeared.

Robert I. Randolph outlined the northern Indiana sewage-disposal problem, indicating the failure of the idea of a sanitary district to cover the whole area; breaking up the region into three districts is possible.

L. R. Howson said Gary has recently had its plans of four years ago brought to date and is proceeding with parts of the plan. Both Racine and Kenosha are building intercepters preliminary to disposal, for which plans have been drawn.

St. Joseph and Benton Harbor, W. E. Stanley stated, have had their sewage problem studied, intercepting collection systems laid out, and disposal sites chosen.

The present officers were re-elected for the ensuing year.

Investigations Under Way on St. Francis Dam Failure

The St. Francis dam failure is being investigated thoroughly by the various interests affected. Besides the investigations of the Los Angeles Water and Power Bureau, owner of the dam; of the officials of Ventura County, where the dam was located; of the district attorney of Los Angeles County, and of the coroner of Los Angeles County, an engineering committee has been appointed by Gov. C. C. Young. On this committee are A. J. Wiley, consulting hydraulic engineer, Boise, Idaho; H. T. Cory, consulting engineer, Los Angeles; Frederick H. Fowler, consulting engineer, San Francisco, and Frank Bonner, California representative of Federal Power Commission and district engineer of the United States Forest Service. In appointing this committee Governor Young stated:

"The prosperity of California is largely tied up with the storage of its flood waters. We cannot have reservoirs without dams. These dams must be made safe for the people living below them. Accordingly our duty is a double one: We must learn, if it is possible, just what caused the failure of the St. Francis dam; the lesson that it teaches must be incorporated in the construction of future dams."

Following the statement of Dr. Elwood Mead, Commissioner of Reclamation, that he would serve as chairman of a committee of engineers chosen from the Am.Soc.C.E., the Los Angeles Chamber of Commerce has asked him to act as chairman of such a committee. The Secretary of the Interior has extended to Dr. Mead the necessary leave of absence.

Truck Causes Collapse of 150-Ft. Through-Truss Bridge Span

Efforts to remove a truck which had broken through the concrete flooring of a bridge over the Schoharie River about 35 miles from Albany, N. Y., resulted in the collapse of one span. About 30 persons who were watching the work on the stalled truck went down with the bridge as it fell 30 ft. to the river below. Thirteen persons were injured, five of them seriously.

The structure was an old iron bridge built in 1888 of two 150-ft. spans. The trusses were of the through type. It is thought that the rope attached to the truss work of the bridge for lifting the truck contributed to the collapse. The truck had been lifted a few feet when something gave way and it dropped back upon the bridge. The resulting vibration in the structure was followed immediately by its collapse.

War Department Permits Boston to Go to Ware River for Water Supply

The Metropolitan District Water Supply Commission, Boston, Mass., has been notified by the War Department that, subject to limitations noted below, there will be no opposition to the diversion of water from the Ware River for the supply of the district but that further investigations are needed before a decision is reached as to the diversion of water from the Swift River. Both rivers lie wholly within the State of Massachusetts, but through the Quaboag and Chicopee rivers successively they flow into the Connecticut River, above the Massachusetts - Connecticut boundary line.

No storage on the Ware River is proposed and no diversion except when the flow is in excess of 85 m.g.d., or about 131 sec.-ft. Under the War Department permit there will be no diversion whatever from the Ware except between Oct. 15 and June 15. The Massachusetts enabling act requires approval by the State Department of Public Health for any diversion from the Ware between May 31 and Dec. 1.

The announcement issued by the War Department under date of March 14 states that at a hearing granted to the states of Massachusetts and Connecticut on Feb. 9, "no attempt was made by either side to controvert the finding set forth in the notice of hearing that the navigable depth of the Connecticut will not be affected by diversion between Oct. 15 and June 15 *except* to the extent of an average of 0.6 of a day per year."

The case, as regards the proposed diversion of the Swift River, is quite different in view of the fact that a large amount of storage of its water is proposed and that a "very large proportional diversion" from the Swift is proposed.

The drainage areas in square miles of the three rivers concerned are given in the War Department statement as follows: Ware, above the point of diversion, 98; Swift, above lower end of proposed reservoir, 186; Connecticut, about 11,000.

Massachusetts Gasoline Tax Again Defeated

The House ways and means committee of the Massachusetts Legislature rapidly disposed of a bill providing for a tax of 2c. a gallon and a reduction of 70 per cent in registration fees for automobiles and motor trucks by referring it to the next annual session. The bill follows closely the recommendations of Governor Fuller.

Arthur Kill Bridge Named for General Goethals

The bridge over the Arthur Kill between Elizabeth, N. J., and Howland Hook, Staten Island, will be named in honor of the late Gen. George W. Goethals, under the terms of a resolution recently passed by the Port of New York Authority. General Goethals became consulting engineer of the New York-New Jersey Port and Harbor Development Commission following his services as state highway engineer of New Jersey ten years ago and was appointed to the Port Authority staff upon the latter's creation in 1921.

The Arthur Kill bridge between Perth Amboy, N. J., and Tottenville, Staten Island, already has been christened the Outerbridge Crossing in honor of Eugenius H. Outerbridge, who was the first chairman of the Port Authority. Both the Outerbridge Crossing and the Goethals Bridge will be opened simultaneously to traffic in midsummer, which will be more than six months earlier than had been promised, according to the Port of New York Authority.

One Application Withdrawn for Power Project on White River

The Ozarks Hydro Electric Company has withdrawn its application made to the Federal Power Commission for a preliminary permit covering a 200,000-hp. project on the White River near Cotter, Ark. The commission now is in a position to act promptly on the conflicting application of the White River Power Company.

This marks a definite step in a project that has been through many vicissitudes. The original application for this site was filed by the Dixie Power Company, which received a preliminary permit but failed in its effort to provide for the construction of the project. Upon the expiration of this permit the two applications mentioned were filed. At the request of the two applicants, the commission withheld action so as to give the applicants an opportunity to work out an agreement between themselves. This apparently has been accomplished.

The project is closely related to that on the upper White River across the line in Missouri, where the Empire District Electric Company has applied for a license covering an 80,000-hp. project at Table Rock. The commission is withholding action on this application because the local county officials are insisting that the power company build a bridge over its reservoir that would cost in excess of $500,000.

Highway Short Course at North Carolina State College

A very successful short course for highway and municipal engineers has just been completed at North Carolina State College of Agriculture and Engineering, according to Harry Tucker, professor of highway engineering. The course lasted four days and was attended by engineers from all sections of the state. The course consisted of both lectures and laboratory work.

Among the lecturers for the course were: A. A. Anderson, road engineer, Portland Cement Association; J. E. Griffin, engineer, National Paving Brick Manufacturers Association; W. A. Harris, chemical engineer, North Carolina State Highway Commission; A. L. Hooper, highway engineer, Raleigh, N. C.; W. E. Rosengarten, engineer for the Asphalt Association; and T. S. Johnson, consulting engineer, Raleigh.

Los Angeles Aqueduct Dynamiter Confesses in Court

As a result of investigations of the dynamiting of the Los Angeles aqueduct, Perry Sexton, Jr., a rancher, told on the witness stand March 12 details of the dynamiting of No Name Canyon siphon, in which he and others participated. Sexton's confession implicates the Watterson brothers, now serving sentences in the state prison for illegal bank operations in Owens Valley.

Contract Let for High Dam of Reinforced Concrete in Mexico

Contract for the construction of a reinforced-concrete dam 255 ft. high in the northern district of Lower California, about 11 miles south of the international boundary, has been let to the Ambursen Construction Company, New York, for $300,000. The dam is to be built on the Tijuana River at a point about 30 miles from San Diego. The water from the reservoir so formed will be used for the municipal water supply of Tijuana and San Diego and also for irrigation purposes. The dam will be the highest of its type yet built.

Architects to Study Health and Safety of Building Trades

A committee of architects, headed by D. Everett Waid, and composed of seven members of the New York Chapter of the American Institute of Architects, is planning a nation-wide study of health and safety in the building industry. Members of the committee in addition to Mr. Waid are William P. Bannister, Lansing C. Holden, William H. Beers, S. R. Bishop, Theodore I. Coe and Rudolph P. Miller.

RAILWAY DESTRUCTION CAUSED BY FAILURE OF ST. FRANCIS DAM

Site of one of the Southern Pacific bridges. A channel now 500 ft. wide where formerly a 150-ft. span was sufficient. Both the span and stone piers were completely swept away.

State Health Departments Unite to Protect Great Lakes

The executive health officers of the eight states bordering on the Great Lakes on March 7 adopted the following resolution, known as the Great Lakes drainage basin sanitary agreement:

Resolved, That the Departments of Health of the states of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York, represented by the executive health officers of said departments of health, do hereby agree to co-operate with each other and with the United States Public Health Service in carrying out a policy for the improvement of the quality of the waters of these interstate lakes and their tributary streams in these states by the prevention or correction of undue pollution thereof, to the end that the said lakes and tributary streams may be maintained or rendered suitable sources of public water supplies as aforesaid.

To carry on the proposed work, so far as the eight states are concerned, the meeting chose as chairman Dr. W. F. King, health officer of Indiana, and as secretary Dr. I. D. Rawlings, health officer of Illinois. According to *Ohio Health News:*

"The agreement conforms to the general lines and is for similar purpose, as affecting the Great Lakes, as the interstate agreement of the Ohio River drainage basin, which has been in effective operation for nearly four years."

Decide on Height of San Gabriel Dam

Decision in the suit over the height of the proposed $25,000,000 San Gabriel dam of the Los Angeles County flood-control district, handed down March 9 by the Superior Court of California, held that since there has been no "change of conditions" the dam must be 425 ft. high as originally proposed. This is in accordance with the plan of J. W. Reagan, former flood-control district engineer, and contrary to recommendations of the engineering board retained to advise the county in the dispute over the dam height. (See *Engineering News-Record* Oct. 6, 1927, p. 563). When the court decision was announced county officials indicated that they would advertise immediately for bids on the high dam.

Dr. Harvey Nathaniel Davis New President of Stevens Institute

Dr. Harvey Nathaniel Davis, now occupying a chair of mechanical engineering at Harvard University, has been selected president of the Stevens Institute of Technology, at Hoboken, N. J., to succeed the late Dr. Alexander C. Humphreys, who resigned last June upon the completion of 25 years of service. Dr. Davis will assume his new duties on Sept. 1 next. Since Dr. Humphreys' death, Aug. 14, Dr. Frank L. Sevenoak, a member of the faculty, has served as acting president.

Dr. Davis is 47 years old. He has been professor of mechanical engineering at Harvard since 1919 and previously served as instructor and assistant professor in physics there. Outside of the educational field, his activities have included the position of engineer in the turbine department of the General Electric Company, aeronautical mechanical engineer in the United States Air Service and consulting engineer, U. S. Bureau of Mines. He has also been employed by the Franklin Railway Supply Company and the Air Reduction Company.

Montreal Next Meeting Place of N.E.W.W. Association

Choice of Montreal, Que., as the next meeting place of the annual convention of the New England Water Works Association was announced at the luncheon meeting of the association held in Boston on March 14. It was stated that the decision was based largely upon the wishes of the Water Works Manufacturers Association and of the New York Section of the American Water Works Association, in view of the fact that the A.W.W.A. is to journey to San Francisco for its annual meeting this year, thus making a nearby meeting place for the N.E.W.W.A. desirable. Opinion was expressed that not only the New York section but some of the other Eastern sections of the A.W.W.A. would be represented at the Montreal convention, making a total estimated attendance of 800. Proposals for excursions on the part of the N.E.W.W.A. to Bermuda, Atlantic City and down the St. Lawrence and Saguenay rivers have been under consideration.

The death was announced of the single previously living charter member of the New England Water Works Association, Frank E. Hall, a past president.

There were nearly 200 members in attendance at the meeting on March 14. Except for the business matters already mentioned, the afternoon was devoted entirely to the presentation and discussion of the N.E.W.W.A. committee on cross-connections, abstracted elsewhere in this issue. Following a lively discussion, action on the report of the committee was postponed until after the publication of the full report of the committee in the *Journal* of the association for June, 1928.

RAILWAY DESTRUCTION CAUSED BY FAILURE OF ST. FRANCIS DAM

Track of the Southern Pacific Railway, 6 miles west of Laugus, Calif., washed off the roadbed and partly overturned by the rush of water down the valley.

Large Welded Factory Building Completed In West Philadelphia

A factory building designed and built according to modern principles of electric arc welding has just been completed at the West Philadelphia plant of the General Electric Company. It covers 80,150 sq.ft., the main portion being approximately 140 ft. wide, 550 ft. long and 50 ft. high. This portion is connected to an existing parallel building by a transept bay across one end, this bay being 78 ft. wide and 170 ft. long. A saving of 12 to 15 per cent of steel tonnage is said to have been effected by using a welded rather than a riveted design. Shop fabrication and field erection each required about two months. As far as can be ascertained, this is the first welded building to be designed and built in compliance with a city building code.

At the regular meeting of the Philadelphia Section, Am.Soc.C.E., March 14, the session was devoted to welding, and specifically to matters relating to this building. In the afternoon of that day, through the courtesy of the General Electric Company, members of the society were taken on an inspection trip through the building.

The structural frame of the main building consists of three lines of columns forming two main aisles over which span parallel chord Pratt trusses about 7-ft. deep. One aisle, open from the floor to the trusses, is devoted to a 10-ton bridge crane runway, while in the other aisle a reinforced-concrete gallery floor is placed about midway between the ground floor level and the lower chords of the roof trusses. The transept bay is open for a 10-ton bridge crane runway and is spanned by trusses similar to those over the main building aisles, except that the top chords are inclined. In the main crane aisle 2-ton wall cranes are carried by brackets supported both by the building columns and by special auxiliary columns. The steel totaled about 989 tons, of which 745 tons was fabricated at the Trenton (N. J.) plant of the American Bridge Company. All unit trusses used were those of the Philadelphia building code. A report of tests on the trusses was published in *Engineering News-Record*, Dec. 22, 1927, p. 720. Another article, more fully describing the welding methods used and the several interesting details of the design, will be published in a future issue of *Engineering News-Record*.

Speakers at the Am.Soc.C.E. meeting included Prof. Frank P. McKibben, consulting engineer, General Electric Company, in charge of the design and erection of the building in co-operation with Harris & Richards, architects; Andrew Vogel, of the General Electric Company; J. H. Edwards, chief engineer, American Bridge Company, and Mr. Hibbs, of the Philadelphia building department.

According to Professor McKibben, there have been about 35 buildings, 25 bridges and about fifteen ships built or repaired in a major way by welding, but this is the first building erected in a city where a building code had to be complied with. The Philadelphia building department issued a special permit for the structure which deviated in only a few details from riveted specifications. A unit stress for welded-joint design of 3,000 lb. per lin.in. for a ⅜-in. fillet weld was one of the main stipulations. It was also required that all welding operators be examined in accordance with best standard practice. The city inspection department expressed its confidence in being able to tell good from bad welds by surface inspection. Professor McKibben listed four major factors the development of which will contribute much to the advancement of welding: (1) Modification of city building codes to include welding; (2) proper control and check of welding employees; (3) development of the use of jigs in shops so as to do away with templets; and (4) development of automatic welding machines that will cut the cost and speed up the work.

New York State Continues Stand Against Cross-Connections

The stand for the abolition of all cross-connections between potable and polluted water supplies, as a menace to public health, taken by the Public Health Council of New York State in November, 1925, is to be continued unabated, notwithstanding protests made by representatives of industry. Under the state sanitary code all such cross-connections in New York State must be abolished by July 1, 1928. Since the reception of the protests, according to a statement adopted by the council on Feb. 23, "the council has repeatedly consulted manufacturers, health officials, water-supply officials, sanitary engineers, fire-protection engineers and insurance-rating officials, as a result of which it has become convinced that the complete severance of potable and polluted waters is demanded for the protection of the public health, and that this can be accomplished without increasing fire hazard to life or property."

Brief News

CONSTRUCTION OF A 66-MILE EXTENSION in Texas to be financed by the Atchison, Topeka & Santa Fe Railway is proposed by the Pecos & Northern Texas Railway, a Santa Fe subsidiary, in an application made public March 10 by the Interstate Commerce Commission. The projected branch would extend from Hale Center, Hale County, Tex., to Palmerton, Palmer County, Tex.

THE ONTARIO GOVERNMENT has asked the Legislature for an appropriation of $2,470,000 for extensions of the provincial hydro-electric power system. This includes $400,000 for the Niagara system, $1,600,000 for the St. Lawrence and Ottawa system, $365,000 for the central Ontario system, $75,000 for the Georgian Bay system, $20,000 for the Nipissing system and $10,000 for the rural extensions in the Sault Ste. Marie district.

A BILL AUTHORIZING an additional $100,000,000 for post office and federal buildings throughout the United States has been signed by President Coolidge. This new law provides funds in addition to the $165,000,000 appropriation voted last session, which provided $100,000,000 for federal buildings in the United States, $50,000,000 for public structures in the District of Columbia, and an unexpended balance of $15,000,000 to be distributed at the discretion of the Post Office and Treasury departments.

THE LOWEST BIDDER for the construction of the new Department of Agriculture administration building in Washington, D. C. was the George Hyman Construction Company, of Washington, with $1,450,000. The George A. Fuller Company was second low bidder, with $1,484,000.

TWO RESEARCH FELLOWSHIPS in engineering are to be appointed, April 30, by the University of Wisconsin. Applications will be received up to April 15 from engineering graduates, preferably from those who have had one or two years of graduate study, or teaching or of engineering experience. Appointments will be for two years, and the salary will be $900 for the first year and $1,100 for the second year.

APPLICATION FOR A RECEIVERSHIP for the City of Indianapolis, brought by taxpayers as a sequel to the recent controversy over who should succeed to the mayoralty, has been denied by the court on the ground that the city is still a going concern.

THE RECORDS OF FIVE SEWER CONTRACTORS in Queens Borough, New York City, have been reported missing and subpoena servers have been unable to locate six desired witnesses since the gathering of preliminary testimony for use in the proceeding for the removal of Borough President Connolly was begun.

A FEDERAL ALLOTMENT of $500,000 has been made for maintenance and improvement of river and harbor works in the Missouri River from Kansas City to the mouth at St. Louis.

THE FIRST NATIONAL MATERIALS HANDLING MEETING ever arranged will take place in Philadelphia on April 23 and 24 at the Hotel Benjamin Franklin under the auspices of the Materials Handling Division of the American Society of Mechanical Engineers. Materials handling in its various phases will be considered by speakers of national prominence.

FOR DREDGING AND CLEANING the Erie Basin in Buffalo, $460,000 has been provided by a bill recently signed by Governor Smith of New York. It is planned to provide a 23-ft. channel.

Washington Notes

Boulder Dam Legislation Progress; Definition Needed of Responsible Bidders; Foreign Materials

By Paul Wooton
Washington Correspondent

THE BOULDER dam bill is now on the calendar in each house of Congress. The measure was reported by the House committee March 15, and from the Senate committee the day following. Minority reports will be made from each committee.

The Senate committee eliminated the provision of the Johnson bill providing for four-state ratification and inserted a plan for six-state ratification coupled with a limitation of 4,600,000 acre-ft. on the amount of water that may be used in California, with an exception that one-half of any surplus may be used in California. Arizona and Nevada are to receive a total of 37½ per cent of the surplus revenues from power at the dam. The percentage is the same as is accorded the states under the oil land leasing act. With California, Nevada and Arizona are to be given preferential rights for the generation or purchase of power for use within the state. The all-American canal is to be repaid under the provisions of the reclamation law. Senator Phipps, of Colorado, chairman of the committee, believes that the amended measure can be passed at this session.

Who Are Responsible Bidders?

An interpretation of the term "responsible bidder" has been requested of the Comptroller General by the Secretary of the Treasury. Removal of the growing uncertainty on the part of awarding officials is particularly desirable at this time when the government is embarking upon a large building program. In cases where low bids were not accepted, awarding officials frequently have been subject to such unpleasant criticism that the tendency has been to be lenient with low bidders in the matter of their ability to carry out the contract. In addition, there has been a tendency on the part of the Comptroller to question awards which do not go to the low bidder. As a result the number of defaulted and improperly performed contracts has increased. The Associated General Contractors recently brought together 21 legal decisions which indicate clearly that the courts regard it as the duty of public officials to make awards only to those who are competent to perform their contracts. One of the main questions from the point of view of Treasury officials is whether every bidder is responsible if he can supply a proper surety bond.

Foreign Building Materials

An attempt has been made to insert a clause in the proposed public contract act of 1928, that, in effect, would limit importation of cement and other foreign commodities for use in public construction. It has become apparent that the cement interests have transferred their efforts to Congress, where a bill has been introduced by Representative Wood, of Indiana, directing purchasing agents to require bidders to specify under each bid the exclusive use of either foreign or domestic material.

It is this procedure that the Associated General Contractors regards as dangerous. The association favors home materials but believes that protection should come through the Tariff Commission. A brief prepared by the Associated General Contractors says: "From the viewpoint of construction, the proposed clause establishes an unfair and discriminatory advantage, which the cement industry has little right to ask. For the purpose of eliminating merely a small amount of foreign competition, it is asking that a detailed procedure be followed, which creates a new difficulty in general contracting and furthermore one in many cases which cannot be complied with. Should this provision be adopted, it will apply not only to cement but to hundreds of other materials. Numerous foreign products, including chemicals, stone, glass, marble, bronze and other items, find their way into this country and move forward without identity as to origin through successive stages of production, until they finally reach the contractor who bids upon the government project. To ask the contractor to trace out the origin of these things, were it possible even, is carrying out the idea of preference for American materials to an impractical degree."

Engineering Societies

Calendar

Annual Meetings

BUILDING OFFICIALS CONFERENCE OF AMERICA, Springfield, Mass.; Annual Meeting, Detroit, Mich., April 24-27.

AMERICAN WELDING SOCIETY, NEW YORK; Annual Meeting, New York, April 25-27.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston, Mass.; Annual Meeting, Atlantic City, May 7-10.

AMERICAN ASSOCIATION OF ENGINEERS, Chicago; Annual Convention, El Paso, Tex., June 4, 5 and 6.

AMERICAN WATER WORKS ASSOCIATION, New York; Annual Convention, San Francisco, week of June 11.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION; Annual Meeting, University of North Carolina, June 25.

THE NEW YORK STATE SOCIETY OF PROFESSIONAL ENGINEERS AND LAND SURVEYORS, which has for its object the promotion of the professional status of the engineer and surveyor through enforcement of the law restricting practice to qualified persons, will hold its annual convention in New York City on Wednesday, March 28. The program consists of an inspection of the Cathedral of St. John the Divine, annual meeting and election of officers, and a dinner at the Hotel Astor in the evening.

THE RUSSIAN ASSOCIATION OF ENGINEERS announces that its president, Leon S. Moisseiff, will deliver a talk in English on "Steels Used for Modern Bridges" on March 30 at 8:30 p.m. in the Engineering Societies Building, New York City.

THE DETROIT ENGINEERING SOCIETY will meet on March 30 and hear an illustrated talk on "The Modern Methods of Manufacturing Finishing Lime" by F. J. Spayth, field engineer of the Finishing Lime Association of Ohio.

Obituary

JAMES O. HEYWORTH, long a prominent figure among the contractors of his native city, died at his home in Lake Forest, a suburb of Chicago, on March 15. Since last August Mr. Heyworth had been in Arizona for treatment of abscesses of the lungs. His ailment had constantly grown worse until, a few days before his death, knowing that a fatal ending was near, the sick man had asked to be returned to his home. He died a few hours after arriving there. A wife, a daughter and a son survive him. James O. Heyworth was born in Chicago in 1866, and was graduated from Yale University in 1888. His early experience on construction work was with the Chicago City Railway, in 1890-92, and then with the Knickerbocker Ice Company, on steam shovel work, until 1895, when he became assistant to the general manager. In 1896-97 he built the old Chicago Coliseum at 63d St. From 1897 to 1904 he was a member of the contracting firm of Christie, Lowe & Heyworth, and was in personal charge of many contracts, including the jetties at Sabine Pass for Port Arthur, Tex., and at Fernandina, Fla.; locks and dams on the Warrior River, Alabama, and the substructure for the bascule bridge of the Baltimore & Ohio Railroad over the Calumet River. In 1904 he was a partner in the firm of Schribner & Heyworth on the Chicago track elevation work of the Pennsylvania Railroad. In 1905 he organized his own firm under the name of James O. Heyworth, Inc., and carried out many large contracts on track elevation, heavy foundation work, hydro-electric plants, large buildings and sections of the North Shore and Sag branches of the Chicago drainage canal. During 1917-19 he was manager of the wooden ship division of the U. S. Shipping Board. Mr. Heyworth was a member of the American Society of Civil Engineers, the Western Society of Engineers and the Society of Naval Architects and Marine Engineers. His inventiveness in special arrangements of equipment and in planning and coordinating construction plant was notable. His pride in construction makes his death a distinct loss to the industry.

Construction Equipment and Materials

A Section Devoted to What the Manufacturer Is Doing for the Engineer and Contractor

Program for Tenth Annual Meeting of Railroad Tie Producers

The National Association of Railroad Tie Producers will hold its tenth annual meeting at Hot Springs, Ark., on April 24 to 26. Two special committees will report on tie statistics and ties for industry tracks, and the program includes an address by J. M. Kurn, president of the St. Louis-San Francisco Railway, and the following papers: "Future Demand for Railroad Ties," by Earl Stimson, chief engineer of maintenance, Baltimore & Ohio Railroad; "Failures of Substitutes for Wood Ties," by Prof. N. C. Brown, New York College of Forestry; "Forests and Floods," by Evan W. Kelly, U. S. Department of Agriculture, and "Gum Wood for Ties," by W. J. Smith, tie and timber agent, Missouri-Kansas-Texas Railway. The secretary of the association is Roy M. Edmonds, 1252 Syndicate Trust Building, St. Louis, Mo.

Business Notes

ARMCO CULVERT MFRS. ASSOCIATION, Middletown, Ohio, announces that J. S. Neibert, formerly road construction engineer, Indiana State Highway Department, has been appointed district engineer for Illinois, Indiana, Michigan and Kentucky.

MILWAUKEE CORRUGATING CO., Milwaukee, Wis., announces a rapid growth for its fireproof material division and a consequent increase in its sales force. H. B. Spackman, formerly of the Northwestern Expanded Metal Co., has been appointed special representative in the fireproofing line; C. C. Banholzer has been assigned to the Wisconsin and northern Michigan territory; J. G. Decker will have his headquarters in Minneapolis and will take care of the northwestern territory; and G. C. Lendon has been assigned to the Detroit territory.

AMERICAN PAULIN SYSTEM, INC., has moved its offices from San Francisco to 1220 Maple Ave., Los Angeles, Calif.

YEOMANS BROTHERS COMPANY, Chicago, announces the appointment of H. F. Kircher & Co., Peoria, Ill., as its representative in the central part of Illinois.

ALLIS-CHALMERS MANUFACTURING COMPANY, Milwaukee, announces the appointment of R. T. Stafford, formerly district manager of the Seattle office, as assistant manager of the electrical department in charge of sales and engineering at Pittsburgh Transformer Works. John Alberts, of the Seattle office, has been appointed district manager, succeeding Mr. Stafford.

EASTERN PAVING BRICK MANUFACTURERS ASSOCIATION, Philadelphia, announces the appointment of Joseph B. Shaw, formerly deputy city engineer of Utica, N. Y., to the position of district engineer of the association, with headquarters at Utica. Another announcement is made that Walter F. Faber, former general manager, Fort Pitt Construction Company, Pittsburgh, has been appointed field engineer of the western district of the association with headquarters at Pittsburgh.

FRANK G. LUKEY, San Francisco, Calif., formerly Western manager for A. Milne & Company, New York City, has resigned to become associated with the Ziv Steel & Wire Company, Chicago, as district manager in San Francisco.

WALLACE L. CALDWELL, formerly president of the Kentucky Rock Asphalt Company and prior to that director of the department of roads and pavements of the Pittsburgh Testing Laboratory, has been elected president of Alabama Rock Asphalt, Inc., with general offices at Birmingham, Ala. Alabama Rock Asphalt, Inc. has just completed its new plant at Margerum, Ala., for the production of Alabama rock asphalt.

LORIMER DUNLEVY has resigned his position as sales manager, Climax Engineering Co., Clinton, Iowa, effective March 15 to take up new duties as general sales manager for O. E. Szekely Co., Holland, Mich., makers of commercial airplane engines and other products now in process of design.

CHARLES E. BEARDSLEY, president, Beardsley & Wolcott Manufacturing Company, has been elected president and a director of Bridgeport Brass Company, Bridgeport, Conn., succeeding Carl F. Dietz.

O. B. AVERY COMPANY, St. Louis, now represents the Chain Belt Company as distributor. The O. B. Avery Company has had a rapid growth during the past five years, making it necessary to move into larger quarters which now provide 7,500 sq.ft. of warehouse space and a yard with a private switch and dock. In the last few months it has opened an office at Little Rock, Ark. Mr. Avery, formerly district manager for the Western Wheeled Scraper Company, is president, and Mr. Jones, formerly district manager of the Northwest Engineering Company, is in charge of sales.

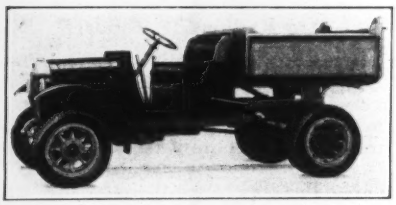
COLORADO PORTLAND CEMENT COMPANY, Fort Colins, Colo., recently opened a new cement plant at Boettcher, Colo., being its third in the state. The capacity of the plant is said to be 3,500 barrels a day, and it has a storage capacity of 240,000 barrels. A new product known as hydroplastic waterproof cement will be manufactured at this mill, the product being originated for use in under-water concrete work.

HITCHCOCK & TINKLER EQUIPMENT COMPANY has been formed to handle the sale of all the plant machinery, camp equipment and supplies used in building the Moffat Tunnel. Hitchcock & Tinkler, Inc., were the contractors on this work.

New Developments

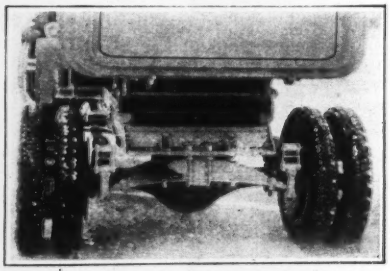
Three New Truck Models for Road-Building Service

Truck models especially designed for road-building work and representing capacities of 1½ yd., 2 yd., and 3½ tons, respectively, have been announced by the Republic Motor Truck Co., Inc., Alma, Mich. The first two are designed for heavy construction work, while the third, of 3½ tons capacity, is a maintenance truck.



1½-YD. GRAVITY DUMP TRUCK

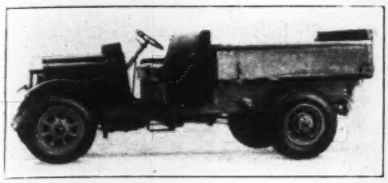
The truck with 1½-yd. capacity, known as Model 88, has an exceptionally heavy frame, large spring shackles, special rear spring design, and a 110-in. wheel base. Either a four-cylinder or a six-cylinder engine is offered as standard equipment



TRANSVERSE SPRING ON GRAVITY DUMP TRUCK

without extra cost. Ample traction is assured by 30x5-in. pneumatic tires. The rear spring construction includes the heavy transverse platform type spring shown in one of the accompanying illustrations, a design developed especially for gravity dump trucks.

The truck of 2-yd. capacity, Model 58, uses a power hoist on its dump body. The heavy frame is tapered over the rear axle in order to obtain the important advantage of low frame height



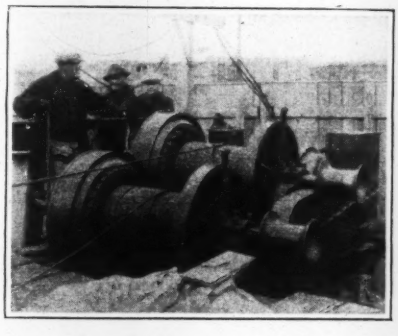
TWO-YARD ROAD-BUILDING MODEL

without sacrificing axle clearance. An important feature of this model is the extra strong, bevel gear rear axle with wide faces to insure long life and dependable efficiency. Either a four-cylinder or six-cylinder engine is offered as standard equipment.

The 3½-ton truck, Model S-25WB, has been designed for severe maintenance work.

Electric Hoist Fitted for Direct or Alternating Current

One of the most important features of the new high speed electric hoist manufactured by the American Hoist & Derrick Company, St. Paul, Minn., is its use of interchangeable electrical equipment. In moving from one job to another ability to utilize either alternating or direct current is advantageous. On this new hoist, by removing a heavy plate which carries the motor, control and resistance unit, a new set of



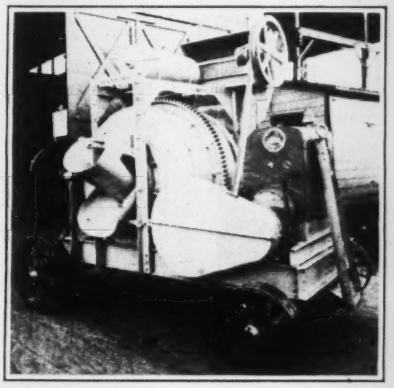
electrical parts attached to another plate can be installed.

The hoists are available in either chain or gear drive. They are made especially speedy and are suited for steel erection service, concrete tower work or general use. A few of the features of the hoist contributing to long life are: Drums machined after being cast; inclosed silent chain drive running in oil; large diameter frictions; large brakes; and an unusually efficient safety brake mounted on the pinion shaft which is claimed to never need adjustment.

For 230 volt direct current the hoists are available from 65 to 125 hp. providing single line loads on a bare drum of from 5,300 to 10,500 pounds. With alternating 3-phase 60-cycle 220-440 volt a.c. current, the hoists are available from 60 to 125 hp., providing single line loads on a bare drum of from 5,000 to 10,500 pounds.

New 14-S Building Mixer

Designed for a three-bag batch of 1:2½:4 proportions, the 14-S standard building mixer recently placed on the market by the Ransome Concrete Machinery Co., Dunellen, N. J., claims as its outstanding feature a simplicity in design that makes all parts easily accessible. The drum is 57 x 42 in. with large radius corners. Feed and dis-



charge openings are 22 in. in diameter. The countershaft is of high carbon steel running in Hyatt roller bearings in self-aligning boxes. Alemite lubrication is used throughout. The main rollers are fitted with Timken roller bearings running on alloy steel shafts. The power loader takes a full load without crowding. All control levers are at the drum end so that the operator can see both the loading and the discharge.

Composition Board Made From Processed Straw

A processed straw building material known as Inso board is a new product of the Stewart Inso Board Company, St. Joseph, Mo. Among the advantages claimed for the boards, which are available 4 ft. wide, ⅛ in. thick and any length that can be conveniently shipped, are excellent heat insulation, suitability for supporting plaster, stucco or roofing material, and efficient sound insulation. The boards are also said to be vermin and insect proof.

The process for fabricating the straw pulp consists of first softening the straw by digestion in steam pressure vessels, which is said to convert compounds in the straw into an excellent adhesive which later in the proces serves to bind the fibers together and renders the board waterproof. The cooked straw, dumped from the pressure vessels, is shredded by suitable machinery, after which the waterproofing material is set on the fibers by use of a reagent and the mass run over a special board machine in which it is formed into a continuous board. The excess water is squeezed out, the board dried and cut to marketable size.

On account of the thorough intermeshing of the long fibers of the straw, the board is claimed to have unusual strength and on account of the fine cellular fibers and consequent air cavities, the high insulating value for the board results.

Manufacturers and Trade Associations

Calendar

Annual Meetings

SOUTHERN PINE ASSOCIATION, New Orleans; Annual meeting, New York City, March 26-28.

AMERICAN WATERWORKS MFGRS. ASSOCIATION, New York City; Annual meeting, San Francisco, Calif., June 11-14.

NATIONAL ASSOCIATION OF RAILROAD TIE PRODUCERS, St. Louis, Mo.; Annual meeting, Hot Springs, Ark., April 24-26.

New Publications

Silent Chain Drives—MORSE CHAIN CO., Ithaca, N. Y., has published a 156-p. thumb-indexed handbook setting forth the proper design and applications for silent chain drives. Engineering factors entering into chain drive design are covered and many illustrations are given. The action, construction, the materials and the method of manufacture of the company's chain are discussed. Tables of typical drives giving all pertinent information are included. Another important feature is a section devoted to methods of installation.

Roller Bearings—TIMKEN ROLLER BEARING COMPANY, Canton, Ohio, has published a small booklet explaining the theory of design used in its tapered roller bearings. At the same time other types of friction bearings are illustrated and described, and the advantages that the company claims for its tapered design over these others are considered.

Metal Caging for Fireproofing—MITCHELL-TAPPEN COMPANY, 15 John St., New York City, has published a pamphlet describing its metal caging for reinforcing the concrete incasement of beams and columns. The pamphlet presents in tabular form the necessary information for ordering metal caging for different sizes of channel, I and H sections. In addition, complete information is given on the method of applying the metal caging.

Business Side of Construction

Facts and Events That Affect Cost and Volume

1928 Foreign Projects Offer Business to American Firms

Construction work proposed this year in various foreign countries includes interesting possibilities for American contractors and manufacturers of equipment and materials. A number of these projects are here listed, and further information may be obtained by addressing the Bureau of Foreign and Domestic Commerce, Washington, giving the proper reference numbers.

Alcohol plant, El Salvador—Concession granted by the Ministry of Finance. San Salvador No. 265,099.

Public works, Costa Rica—Bids are asked on public works in Port Limon, $600,000. Costa Rica 270681.

Hospital, Bogota, Colombia—Plans drawn by American firm for six-story hospital to cost $400,000. Colombia No. 35X 2-20-28.

Water-works, paving, sewers, Porto Alegre, Brazil—Loan of $2,250,000 secured in the United States for completion of city improvement program.

Hotel, St. Andrew Parish, Jamaica—Rebuilding of Constant Spring Hotel, about 8 miles from Kingston, Jamaica No. 267,840.

Oil Storage Tanks, Ecuador—Petroleum storage capacity of 50,000 gal. at Ambato and one of 20,000 gal. in Quito for railroad company. Ecuador No. 266,638.

Railway branch lines, Argentina—Landeta to San Jorge, 24 km.; Landeta to San Francisco, 65 km. Argentina No. 61192.

Recreation resort, Piedras Negras, Mexico—Plans include 10-acre artificial lake, racetracks, tennis courts, parks, exposition buildings, casino and other improvements. Mexico No. 264,279.

Highway, Mexico—Tijuana to Ensenada, $2,000,000. Approval of federal government sought by Governor of Northern District of Lower California (267,064).

Highway, Colombia—LaDorada to Ibague; law passed by Colombian Congress providing for annual appropriation of $150,000 (264,412b).

Highways, Venezuela—El Sombrero to Soledad and Guatire to Carenero, covered by Presidential decree (267,344).

Road, Brazil—Curityba Road, State of Parana, authorized by federal government (266,361g).

Waterworks, Norway—Stavanger plans new works. No. 270695.

Railway, Sumatra—Chief engineer, Government Railways, Bandoeng, Java, recommends a railway line through Middle Sumatra from Loeboeck Lenggan to Kota Penang. Java No. 62,545.

Railway, Persia—Khour-i-Moussa to Hamadan, 680 km., 100 km., of which involves costly gorge work. Persia No. 264,222.

Power plant, Riga, Latvia—Preliminary specifications to be drawn up by commission appointed by Riga city administration. Latvia No. 264,214.

The 1928 construction programs of several governments have recently been announced. Colombia plans public works worth $30,000,000. Chile's plans call for an expenditure of $24,000,000 this year, and $183,000,000 in the next six years. The Spanish government has approved a railway improvement program to cost $102,000,000, of which $39,000,000 is for new construction. As an economy measure the governments of Brazil and Panama are reported to have suspended work on all government projects except those under contract.

More Contracts Let Than Last Year

The number of contracts awarded during January and February, 1928, exceed those awarded last year by 4.6 per cent. This confirms the increased activity in the construction industry as measured by value of contract awards and value of contemplated projects given in last week's issue. The number of contracts for engineering construction projects this year and a year ago were:

	1928	1927
January	670	655
February	639	597
Total	1,309	1,252

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week ended March 22, with some comparisons, total as follows:

(In Thousands of Dollars, 000 Omitted)

Week Ended	Public	Private	Total
Mar. 22, 1928	**22,541**	**53,997**	**76,538**
Mar 15 1928	14,416	35,644	50,060
Mar 24, 1927	21,376	54,071	75,447
Jan 1, to date:			
1928	**203,745**	**487,014**	**690,759**
1927	190,423	417,003	607,426

E. N.-R. Index Numbers

Cost		Volume	
Mar. 1, 1928	**204.65**	**February, 1928**	**225**
Feb. 1, 1928	204.65	January, 1928	208
Mar. 1, 1927	208.80	February, 1927	182
Average, 1927	206.24	Average, 1927	263
Average, 1926	208.03	Average, 1926	228
1913	100.00	1913	100

Average Building Costs Decline Slightly

General construction costs are the same as they were a month ago, but general building costs are 0.425 per cent lower, according to the index numbers of the American Appraisal Company. This holds for three main types—frame, brick with wood frame, and reinforced concrete. The decline is due to lower lumber and labor costs.

In general this is true for all sections of the country. The only departure is that it costs a little more than last month to provide reinforced-concrete buildings in the Pittsburgh district, the Central West, and on the Pacific Coast.

Materials prices have changed negligibly in the last month. The average prices of the chief materials that go into the construction of the four types mentioned are given below for January and February. The drop of ¼c. in labor amounts to 0.45 per cent.

	January	February
Lumber	$50.94	$50.94
Brick	14.62	14.60
Cement	2.20	2.21
Steel, Pittsburgh	1.85	1.85
Common labor	0.55	0.54½

Public Utility Group Leads Bond Offerings

Bond offerings for the week ended March 17, 1928, totaled $80,056,000. This represents a decrease when compared with the preceding week's total of $135,668,000. Public utility offerings were $16,096,000 larger than those of the previous week, and constituted 58 per cent of the total. The leading group during the week ended March 10 was foreign issues, which totaled $45,000,000.

Among more recent foreign offerings was the $10,000,000 City of Warsaw 7s, the proceeds from which will be used for construction and extensions of municipal market halls, water and gas works and other revenue-producing enterprises.

Toledo, Ohio will hold a bond election in November for a $3,000,000 bridge across the Maumee River.

RECENT IMPORTANT BOND OFFERINGS

	(000 Omitted)	Rate	Yield
Public Utility:			
Iowa Power & Light 1st	$6,000	4½	4.80
Utah Pwr. & Lt., 1st lien	5,500	4½	4.79
Atlantic Pub. Serv. Corp.	4,650	5½	5.68
United Pub. Utilities Co.	3,750	5½	5.70
Chester Water Service Co.	3,000	4½	4.80
Atlantic Pub. Serv. Corp.	2,000	6	6.15
Orange & Rockland Elec.	1,250	5	5
Municipal:			
New York State	22,500	3¼,3¾,4	3½–3.65
Allegheny Co., Pa.	3,710	4	3.725
Neuces Co., Tex.	1,500	5	4–4½
Monroe Co., N. Y.	875,000	3¾	3½
Monroe Co., N. Y.	625,000	4	3.80
Huntington, N. Y.	585,000	4	3.85
Asheville, N. C.	500,000	4½	4½–4.30
Foreign:			
Kingdom of Norway, s.f.	30,000	5	5.15
Gelsenkirchen Min. Corp.	15,000	6	6.60
City of Warsaw, Poland	10,000	7	7.95
Porto Alegre, Brazil	2,250	7	7.20

Business Notes

Employment and activity in the manufacturing industry of the United States have been on the increase since November, 1927, according to the January, 1928, returns from 2,000 manufacturing plants reporting to the National Industrial Conference Board. The decline during 1927 amounted to 3½ per cent for the entire year. Despite the decrease in employment, the average weekly earnings per worker employed in January, 1928, were the same as in January, 1927, and a trifle higher than in January, 1926. Average hourly earnings per worker, which reflect the rate of pay for work performed to a greater degree than do weekly earnings, were in January, 1928, more than 2 per cent higher than in January, 1926. This indicates that declining employment, in contrast with the experience of pre-war times, has not brought with it any general wage reduction.

Higher prices of building materials are reported as follows: common brick in New York, up $1 to $16@$19, delivered; wood lath, New York, up $1 to $9.50@$10; Douglas fir in Seattle, up $2 to $24 for 3x12 in. x 20 ft.; linseed oil in Atlanta and Chicago, up ¾c. per 7½-lb. gal., in Minneapolis, up 1½c.